

CVP

3

10795

Waters

FISH TEAM FILE

LOWER YUBA RIVER FISHERIES MANAGEMENT PLAN

February 1991



Department of Fish and Game
State of California
The Resources Agency

C - 0 6 6 7 5 1

C-066751

The Resources Agency
Department of Fish and Game
Stream Evaluation Report
Report No. 91-1

Final Report
Lower Yuba River
Fisheries Management Plan

February, 1991

Douglas P. Wheeler
Secretary for Resources
The Resources Agency

Pete Wilson
Governor
State of California

Pete Bontadelli
Director
Department of
Fish and Game

1. Mitigate New Bullards Bar?

2. Optimize fish?

3. Meet DFG goals?

Lower Yuba River
Fisheries Management Plan, 1/
Keep fish in good condition?

Prepared by

The Resources Agency
Department of Fish and Game 2/

Abstract

Depends on season
sometimes flows are
increased (summer)
& temps decreased.

Data collected during 1986-1988 were evaluated relative to the habitat requirements of the fish and wildlife resources of the lower Yuba River, Yuba County, California. This evaluation is in response to water developments and diversions that have reduced flows and increased water temperatures below Englebright Dam. The lower Yuba River sustains a significant chinook salmon resource. This habitat also sustains steelhead trout, American shad, and a variety of resident game fish and nongame fishes.

Added in
this draft.

Instream flows and temperatures necessary to optimize habitat requirements are identified. Available data do not allow exact definition of habitat requirements for American shad. Further evaluation of the habitat requirements for this species ~~is~~ are recommended to optimize habitat requirements for all anadromous species in the lower Yuba River.

-
- 1/ Investigation funded by the Streamflow Requirements Program, The Resources Agency, Department of Fish and Game, Stream Evaluation Report 91-1, February 1991.
 - 2/ Field data collection by Beak Consultants, Incorporated, Sacramento, California.

TABLE OF CONTENTS

	<u>Page</u>
Abstract	i
Table of Contents	ii
List of Tables	v
List of Figures	viii
Executive Summary and Management Recommendations	xii
Foreword	xiv
Introduction	1
Description of Study Area	2
General Setting and Stream Description	2
History of Development of Yuba River Basin	5
Fish Resources	7
Fall-Run Chinook Salmon	7
Spring-Run Chinook Salmon	9
Steelhead Trout	11
American Shad	12
Striped Bass	14
Hydrology	16
Annual Unimpaired Runoff	18
Monthly Runoff	20
Discussion	21
Conclusions	22
Fish Community Studies	24
Fish Species Composition, Relative Abundance, and Distribution	24
Species Composition	24
Species Relative Abundance and Macrohabitat Use	27
Growth Rates and Condition	28
Conclusions	30

Habitat Criteria	31
Evaluation of Microhabitat Utilization	31
Fall-Run Spawning Chinook Salmon Criteria ...	32
Fall-Run Fry Chinook Salmon Criteria	35
Fall-Run Juvenile Chinook Salmon Criteria ...	37
Steelhead Trout Criteria	41
Water Temperature	41
Fall-Run Chinook Salmon	41
Spring-Run Chinook Salmon	41
Steelhead Trout	43
American Shad	43
Discussion	43
Conclusions	43
Water Temperature	45
Existing Water Temperature	45
Potential Effects of Existing Water Temperature on	
Anadromous Fishes	47
Fall-Run Chinook Salmon	47
Spring-Run Chinook Salmon	49
Steelhead Trout	50
American Shad	51
Water Temperature Modeling	52
Meteorology	52
Hydrology	52
Stream Geometry	53
Model Calibration	53
Temperature Simulation	55
Conclusions	56
Aquatic Habitat and Stream Discharge Relationships	65
Application of IFIM/PHABSIM on the lower	
Yuba River	65
Habitat Mapping	66
Transect Selection	67
Data Collection	69
Data Analysis	70
Transect Weighting and Analysis	71
Fall- and Spring-Run Chinook Salmon	71
Steelhead Trout	72
American Shad	80
Conclusions	81
Water Quality Conditions	84
Point Discharges	84
Non-Point Discharges	85
General Water Quality Characteristics of the	
Lower Yuba River	85
Inorganic Elements	86
Other Substances or Compounds	86
Conclusions	87

Channel Stability Analysis and Spawning Gravel Resources Assessment	88
Historical Channel Stability	88
Gravel Resources Assessment	88
Conclusions	90
Barriers to Anadromous Fish Migration	92
Conclusions	95
Effects of Flow Diversions on Juvenile Anadromous Salmonids	96
Location and Characteristics of Diversions	96
Entrainment and Impingement at Diversions	96
Natural Predation on Juvenile Chinook Salmon	99
Conclusions	100
Riparian Vegetation	101
Existing Plant Communities	101
Comparison of Existing and Historical Vegetative Cover	102
Conclusions	103
Public Recreation and Access	105
Conclusions	105
Instream Flow and Management Recommendations	107
Acknowledgments	115
References	116
Appendix I: Lower Yuba River Discharge for 1969 to 1988 Water Years	124
Appendix II: Tables Corresponding to WUA Figures in Text for Chinook Salmon	129
Appendix III: Tables Corresponding to WUA Figures in Text for Steelhead Trout	149
Appendix IV: Water Quality Data from the Lower Yuba River	166
Appendix V: 1965 Agreement Between the Yuba County Water Agency and the California Department of Fish and Game	185
Appendix VI: Results of PHABSIM at Selected IFIM Transect Sites for Assessment of Upstream Migration Conditions	194

*Not in
Beak Report*

LIST OF TABLES

<u>Table</u>	<u>Page</u>
1. Common and scientific names of fishes occurring in the Yuba River above Marysville, California ..	8
2. Estimated fall-chinook salmon runs in the Yuba River, 1953-1989	9
3. Stocking of hatchery-reared spring-run chinook salmon and steelhead trout in the lower Yuba River from 1970 through 1980	11
4. Estimated unimpaired flow (acre-feet x 1,000) at USGS gage station 11419000 at Smartville, lower Yuba River, California	19
5. Mean monthly flows for the lower Yuba River, California, from monthly estimates of unimpaired flow at USGS gage station 11419000 located at Smartville for water years 1921-1983, and from mean daily impaired flow records for water years 1969-1988 for USGS gage stations located below Englebright Dam (11418000) and near Marysville (11421000)	20
6. List of fishes (all age classes) collected by electrofishing in the lower Yuba River, California, February and May 1987	26
7. List of fishes (all age classes) collected by snorkeling in the lower Yuba River, California, in May 1988	26
8. Average fork lengths (in) and condition factor of juvenile chinook salmon captured by electrofishing during February and May in the lower Yuba River, California	28
9. Classification system used for estimating substrate composition during fish habitat use observations in the lower Yuba River, California, 1986-1987	32
10. Habitat use observations for three life stages of fall-run chinook salmon in the lower Yuba River, California, 1986-1987	33

11.	Total depth and mean column velocity habitat use criteria for fry, juvenile, and spawning fall-run chinook salmon in the lower Yuba River, California, 1986-1987. Criteria developed by the non-parametric tolerance limit method	34
12.	Dominant substrate utilization criteria for spawning chinook salmon in the lower Yuba River, California, 1986-1987	37
13.	Preferred water temperature (^o F) ranges for various life stages of fall- and spring-run chinook salmon, steelhead trout, and American shad	42
14.	List of major node types, distances, and locations downstream of Englebright Dam to the confluence with the Feather River, used in the instream water temperature model of the lower Yuba River, California, 1987	53
15.	List of months and years used for calibration of the instream water temperature model, along with the statistical measures of model performance ...	54
16.	List of months and years of data used for simulating warm, normal, and cool meteorological conditions, lower Yuba River, California	55
17.	Habitat categories, distances, and number of transects in the lower Yuba River, California, study area by study reach	68
18.	Streamflows measured by study reach and transect for instream flow computer model calibration, lower Yuba River, California	69
19.	List of parameters commonly used to describe general water quality conditions	85
20.	Summary of diversion rates (AF) by month for the major water districts supplied by the Yuba County Water Agency, lower Yuba River, California	98
21.	Estimated extent of linear features along the lower Yuba River, California, in 1986	102

22.	Estimated extent of linear features along the lower Yuba River, California, during the early 1970's	103
23.	Estimated Yuba River mean monthly unimpaired flow at Smartville for the 63-year period 1921-1983, actual flow at Marysville gage for the 1969-1988 period, and proposed minimum flow regime at Marysville, California	110

LIST OF FIGURES

<u>Figure</u>	<u>Page</u>
1. Yuba River basin, California	3
2. Lower Yuba River study area, California	4
3. Life history periodicity for fall- and spring-run chinook salmon, steelhead trout, and American shad in the lower Yuba River, California	10
4. Schematic diagram showing diversions and storage in the Yuba River basin, California	17
5. Comparison of mean monthly flows at selected USGS gage stations located at Smartville (gage 11419000, estimated unimpaired flows for water years 1921-1983), below Englebright Dam (gage 11418000, impaired flows for water years 1969-1988), and near Marysville (gage 1142100, impaired flows for water years 1969-1988), lower Yuba River, California	21
6. Overall relative abundance (percent of total number) of all fish species collected by electrofishing and observed by snorkeling in the lower Yuba River, California	27
7. Average fish densities (fish per 1,000 linear ft) of all species observed by snorkeling in deep pool, shallow pool, run/glide, and riffle habitat types in the lower Yuba River, California, May 1988	29
8. Chinook salmon spawning total depth use frequency and probability in the lower Yuba River, California	36
9. Chinook salmon spawning mean column velocity use frequency and probability in the lower Yuba River, California	36
10. Chinook salmon spawning substrate use frequency and use probability in the lower Yuba River, California	38
11. Chinook salmon fry total depth use frequency and use probability in the lower Yuba River, California	39

12.	Chinook salmon fry mean column velocity use frequency and use probability in the lower Yuba River, California	39
13.	Chinook salmon juvenile total depth use frequency and use probability in the lower Yuba River, California	40
14.	Chinook salmon juvenile mean column velocity use frequency and use probability in the lower Yuba River, California	40
15.	Comparison of range of lower Yuba River maximum and minimum daily water temperatures near Marysville, California, before (1963-69) and after (1972-76) construction and operation of New Bullards Bar Dam	46
16.	Mean maximum (Max) and minimum (Min) weekly water temperatures below Englebright Dam (BE) and near Marysville (NM), California, for water years 1973 through 1978	48
17.	Simulated lower Yuba River, California water temperatures for April weather. The alternative flow discharges evaluated are 245/245 cfs and 400/400 cfs (releases at Englebright Dam/below Daguerre Point Dam) with no diversion; 745/245 cfs with 500 cfs diversion; and 1,245/245 cfs, 1,500/500 cfs, 2,000/1,000, and 3,000/2,000 cfs with 1,000 cfs diversion	57
18.	Simulated lower Yuba River, California water temperatures for May weather. The alternative flow discharges evaluated are 245/245 cfs and 400/400 cfs (releases at Englebright Dam/below Daguerre Point Dam) with no diversion; 745/245 cfs with 500 cfs diversion; and 1,245/245 cfs, 1,500/500 cfs, 2,000/1,000, and 3,000/2,000 cfs with 1,000 cfs diversion	58
19.	Simulated lower Yuba River, California water temperatures for June weather. The alternative flow discharges evaluated are 245/245 cfs and 400/400 cfs (releases at Englebright Dam/below Daguerre Point Dam) with no diversion; 745/245 cfs with 500 cfs diversion; and 1,245/245 cfs, 1,500/500 cfs, 2,000/1,000, and 3,000/2,000 cfs with 1,000 cfs diversion	59

20.	Simulated lower Yuba River, California water temperatures for October weather. The alternative flow discharges evaluated are 245/245 cfs and 400/400 cfs (releases at Englebright Dam/below Daguerre Point Dam) with no diversion; 745/245 cfs with 500 cfs diversion; and 1,245/245 cfs, 1,500/500 cfs, 2,000/1,000, and 3,000/2,000 cfs with 1,000 cfs diversion	60
21.	Simulated lower Yuba River, California water temperatures for November weather. The alternative flow discharges evaluated are 245/245 cfs and 400/400 cfs (releases at Englebright Dam/below Daguerre Point Dam) with no diversion; 745/245 cfs with 500 cfs diversion; and 1,245/245 cfs, 1,500/500 cfs, 2,000/1,000, and 3,000/2,000 cfs with 1,000 cfs diversion	61
22.	Chinook salmon spawning, fry, and juvenile WUA/stream discharge relationships in the lower Yuba River, California	72
23.	Chinook salmon fry WUA/stream discharge relationships for the Simpson Lane (Simp), Daguerre Point Dam (Dagu), Garcia Gravel Pit (Garc), and Narrows (Narr) study reaches, and for the riffle (Riff), run/glide (R/G), shallow pool (SP), and deep pool (DP) habitat types in the lower Yuba River, California	73
24.	Chinook salmon juvenile WUA/stream discharge relationships for the Simpson Lane (Simp), Daguerre Point Dam (Dagu), Garcia Gravel Pit (Garc), and Narrows (Narr) study reaches, and for the riffle (Riff), run/glide (R/G), shallow pool (SP), and deep pool (DP) habitat types in the lower Yuba River, California	74
25.	Chinook salmon spawning WUA/stream discharge relationships for the Simpson Lane (Simp), Daguerre Point Dam (Dagu), Garcia Gravel Pit (Garc), and Narrows (Narr) study reaches, and for the riffle (Riff), run/glide (R/G), shallow pool (SP), and deep pool (DP) habitat types in the lower Yuba River, California	75
26.	Steelhead trout spawning, fry, and juvenile WUA/stream discharge relationships in the lower Yuba River, California	76

-x-

27.	Steelhead trout fry WUA/stream discharge relationships for the Simpson Lane (Simp), Daguerre Point Dam (Dagu), Garcia Gravel Pit (Garc), and Narrows (Narr) study reaches, and for the riffle (Riff), run/glide (R/G), shallow pool (SP), and deep pool (DP) habitat types in the lower Yuba River, California	77
28.	Steelhead trout juvenile WUA/stream discharge relationships for the Simpson Lane (Simp), Daguerre Point Dam (Dagu), Garcia Gravel Pit (Garc), and Narrows (Narr) study reaches, and for the riffle (Riff), run/glide (R/G), shallow pool (SP), and deep pool (DP) habitat types in the lower Yuba River, California	78
29.	Steelhead trout spawning WUA/stream discharge relationships for the Simpson Lane (Simp), Daguerre Point Dam (Dagu), Garcia Gravel Pit (Garc), and Narrows (Narr) study reaches, and for the riffle (Riff), run/glide (R/G), shallow pool (SP), and deep pool (DP) habitat types in the lower Yuba River, California	79
30.	Passage of peak hydraulic mining debris as recorded by minimum river stages, Yuba and Sacramento rivers, California	89
31.	Height of stream channel to water surface elevation (ft) at Simpson Lane IFIM Transect-1 site, lower Yuba River, California. Depths measured at 84 cfs, depths estimated using PHABSIM for flows of 50 and 100 cfs	94
32.	Height of stream channel to water surface elevation (ft) at Simpson Lane Critical Riffle Thalweg site at 84 cfs, lower Yuba River, California	95
33.	Location of diversions, lower Yuba River, California	97
34.	Proposed minimum fisheries flow regime at Marysville compared with estimated mean monthly unimpaired flow at Smartville (gage 11419000) for water years 1921-1983 and actual flow recorded at Marysville (gage 11421000) for water years 1969-1988, lower Yuba River, California	111

EXECUTIVE SUMMARY AND MANAGEMENT RECOMMENDATIONS

The lower Yuba River between Englebright Dam and its confluence with the Feather River near Marysville (approximately 24 river miles) was the subject of a 3-year study to identify problems and fisheries management needs of chinook salmon (Oncorhynchus tshawytscha), steelhead trout (Oncorhynchus mykiss), and American shad (Alosa sapidissima).

The Yuba River is recognized as a significant producer of naturally spawned salmon and steelhead and was once known nationwide for its outstanding shad fishery. However, while limited evidence indicates Yuba River steelhead populations may have increased following the completion of New Bullards Bar Dam, substantial evidence shows chinook salmon populations have not, and the shad fishery was almost nonexistent for a number of years.

Water developments and diversions have had significant impacts on fisheries of the Yuba River. As a result of such developments, flows in the river have been substantially reduced and temperature modified from that naturally occurring. Flow reductions have affected salmon and steelhead reproduction, growth, and migration, and shad attraction, passage, and spawning.

As the initial step in an effort to develop solutions to fisheries problems in the Yuba River, a series of detailed studies involving stream temperatures, flow-habitat relationships, water quality, fish populations, fish passage, fish growth, riparian habitat and impacts of diversions were completed. The data collection portions of the study were completed by Beak Consultants, Incorporated, under contract to the California Department of Fish and Game (DFG). This report relies on these data plus records and knowledge of the DFG.

Due to its value to both the sport and commercial sectors, chinook salmon are considered of primary importance in management of the lower Yuba River. Therefore, this study primarily develops recommendations to protect chinook salmon. However, since life stage requirements for steelhead are generally similar, steelhead should be benefited by management proposals for salmon. Habitat requirements for American shad are significantly different from salmon and steelhead as are their times of use of the Yuba River. There is little conflict between the needs for shad and salmon and steelhead.

Based on the analyses of these and other studies, DFG recommends the following conditions to optimize habitat conditions for the restoration, maintenance, and protection of chinook salmon, steelhead trout, and American shad.

To what levels

Ps 108 goals are to optimize habitat conditions & populations

-xii-

Section taken out stating that "plan was developed in accordance with Public Resources Code sections 10002 and 10003 and to meet the goals of Section 6900 et seq. of the Fish and Game Code."

Streamflow and Temperature

The following streamflows and temperatures are recommended to be maintained in the lower Yuba River:

Month	Temperature (°F) - mean daily at:		Minimum streamflow at	
	Daguerre Point Dam	Marysville gage	Marysville gage (cfs)*	
Oct 1-14	NR+	60	450	
Oct 15-31	56	57	700	Supporting evidence on Pg 64
Nov 1-Mar 31	56	57	700	
Apr	60	60	1,000	Supporting evidence on Pg 64 & based on temp.
May	NR	60	2,000	
Jun	NR	65	1,500	
Jul	65	NR	450	
Aug	65	NR	450	
Sep	NR	65	450	

* U.S. Geological Survey streamflow gage no. 1142100, located 4.2 mi east of Marysville.

+ NR = no requirement.

Draft stated that May/June Temps should be maintained between 60-65°F for American Shad

has 24 hrs. How do you manage for this difficult
Daily maximum temperatures should not exceed the daily average by more than 2°F and such exceedence shall not occur for more than 8 hours (h) in any 24-h period. Water temperature criteria will not apply during defined "dry" water years for the Yuba River drainage (a "dry" water year is defined below).

was "shall"
Reductions to minimum flow schedule during "dry" water years should occur under an equitably balanced use of the resource with the same percentage reductions made to diverters as to the fisheries minimum flow. Such reductions shall be based on water available to permanent contracts in existence on January 1, 1990. Post January 1, 1990 offstream contractual obligations and diversion shall be reduced to zero before reductions in fishery flows occur. A "dry" water year is defined as less than 50% of the 50-year average unimpaired runoff of the Yuba River in acre-feet at Smartville for the current water year as published annually in the May 1, Report of Water Conditions in California by the California Department of Water Resources.

Short-Term Daily Streamflow Fluctuation

Short-term daily streamflow fluctuations are defined as changes in flow that occur on a regular daily basis generally associated with daily operations of hydroelectric power generation and deliveries to offstream diverters. To avoid loss of aquatic productivity and to prevent fish stranding, daily flow fluctuations should not exceed 10% of the average flow within any 24-h period and weekly

flow fluctuations should not exceed 20% of the average flow within any 7-day (d) period at all times while Yuba River releases from New Bullards Bar Reservoir and Englebright Reservoir are under control (i.e., no unregulated spills are occurring). For example, if the average flow for the period is 200 cfs, flows should not be less than 180 cfs or greater than 220 cfs on a daily basis; flows on a weekly basis should not be less than 160 cfs or greater than 240 cfs. Flow fluctuations should be measured at the USGS gage stations located below Englebright Dam and near Marysville.

Streamflow Reduction

Streamflow reductions are defined as planned reductions. Such reductions are generally associated with, but not limited to, the specified monthly flow schedule above, reservoir flood reservation requirements, deliveries to offstream diverters, water transfers and sales, and downstream salinity intrusion control. During all such flow reductions the ramping rate should be gradual, not exceeding 30% of the existing initial flow during any 24-h period, and subject to stranding studies.

To further reduce the impacts from flow reduction during October 15 through February, the following interim schedule, subject to stranding studies, is recommended to reduce the negative impacts of dewatered redds, net loss of spawning gravels, and loss of juveniles to stranding. In the event that during the period October 15 through February, the 7-d average flow from Englebright Dam (except in the event of flood control releases) exceeds 800 cfs, the above monthly flow schedule shall be modified in accordance with the following schedule:

1. If the average flow for the preceding 7-d period exceeds 800 cfs but is less than 1,000 cfs, the minimum flow specified in the above flow schedule should be 800 cfs from October 15 through February at the Marysville gage.
2. If the average flow for the preceding 7-d period exceeds 1,000 cfs but is less than 1,500 cfs, the minimum flow specified in the above schedule should be 1,000 cfs from October 15 through February at the Marysville gage.
3. If the average flow for the preceding 7-d period exceeds 1,500 cfs, the minimum flow specified in the above schedule should be 1,500 cfs from October 15 through February at the Marysville gage.

Between May 1 and June 30, the following schedule, measured at the Marysville gage, is recommended for maintenance of American shad angler success:

4. During May 1 through May 31, a weekly flow reduction not greater than 200 cfs.

5. During June 1 through June 30, a weekly flow reduction not greater than 150 cfs.

i.e. data sketchy

*Are studies
proposed to
address
these
questions.*

The April, May, and June flows of 1,000, 2,000, and 1,500 cfs, respectively, are interim flows subject to evaluation studies for adult American shad attraction and spawning, spring-run chinook salmon attraction, and for fall-run and spring-run chinook salmon, and steelhead outmigration.

Water Quality

*Covered by
other agency*

The following water quality parameters are to be maintained in receiving waters below Englebright Dam and Daguerre Point Dam:

1. Dissolved oxygen not to be less than 7.0 ppm.
2. The pH not to exceed the range of 6.5-8.5.
3. No discharge of heavy metals or other constituents which cause chronic or acute toxicity to any life stage of the aquatic resources.
4. No discharge of turbid water or water containing settleable solids in excess of California Regional Water Quality Control Board (RWQCB) Basin Plan Standards.

*How do we
control pH*

Habitat Protection and Improvement

*Not under
Yuba control
How much
is going on?*

*There never
has been
any gravel
here, most
likely*

Spawning gravel conditions within the Yuba River are generally excellent. However, in the upstream area no new recruitment of gravel can occur due to the presence of Englebright Dam. Gravel extraction within the area between Daguerre Point Dam and Englebright Dam should be carefully evaluated and monitored. Gravel of suitable quality and quantity should be placed at locations between the Narrows and Englebright Dam to improve the spawning conditions for adult spring-run chinook salmon. Future licenses and permits for projects on the Yuba River should be conditioned to provide for gravel replenishment, as necessary. To preserve existing and future spawning gravels, salmonid spawning habitat should be maintained through conditions that prevent sedimentation and gravel cementation. *Add*

Gravel extraction within the Yuba River flood plain should be restricted to skimming type operations that only remove materials not suitable as substrate for spawning chinook salmon and steelhead. Excavations below the thalweg should be allowed only behind levees capable of protecting the work area from a 100-year flood event. No activities should be allowed which could result in changes in channel location.

Habitat for fry and juvenile salmon and steelhead is currently less than optimum. Channel narrowing and degradation have reduced

Spawning needs could be more likely in a structure is what is needed for cover.

available habitat for these life stages. Habitat improvement projects should be implemented and should include construction of shallow "rearing" areas and "braided" channels designed to optimize habitat requirements for fry and juveniles. Stocking of additional steelhead fry should be considered to increase steelhead populations.

pg 92 says "no activities should be allowed which could result in changes in channel location."

Water Diversion and Fish Screens

In accordance with Fish and Game Code Section 6100, all new diversions of water from the Yuba River should be screened according to criteria established by the DFG. Existing water diversions from the Yuba River (Brophy, South Yuba, Browns Valley, and Hallwood-Cordua Irrigation districts) are resulting in losses of fry and juvenile salmon and steelhead. Existing gravel and weir type fish screens have proven unreliable and ineffective and should be replaced and screened according to current DFG criteria. All diversions of water should be screened with "state of the art" perforated plate or wedge wire type screens located "on river".

Riparian Habitat Maintenance and Protection

Riparian vegetation along the lower Yuba River is valuable as it provides food (terrestrial insects) for juvenile salmon and steelhead, nutrient input to the river system, and is used by many wildlife species. Removal of this vegetation should be carefully evaluated to assure no net loss to protect fish and wildlife resources. Riparian vegetation is included in the California Fish and Game Commission's definition of wetland vegetation and compensation must be sought in line with Commission policy. Programs for restoration and improvement of riparian habitat should be implemented.

DFG recommends that the Yuba County Water Agency (YCWA) provide funds for acquisition of acreage of lands adjacent to the Yuba River below Englebright Dam as an alternative to the wildlife habitat mitigation provisions of the Agreement between DFG and the YCWA for New Bullards Bar. Such land should be maintained for habitat protection and fish and wildlife oriented recreation by DFG with annual funds for habitat improvement and protection provided by the YCWA.

Public Access for Recreation

Public access should be provided at selected locations along the lower Yuba River to provide for a wide base of recreational activities such as boating/rafting, fishing, and bird watching. Public access and appropriate facilities should be developed at the following general areas:

1. Rose Bar, approximately 3 mi upstream of the Highway 20 Bridge on the south side of the river.

2. Parks Bar at Highway 20 bridge crossing. This could be associated with the rebuilding of the bridge by the California Department of Transportation.
3. Daguerre Point Dam area, on the north side of river.
4. Hallwood Avenue or Walnut Avenue, on the north side of river.

Project Coordination

The Pacific Gas and Electric Company (PG&E) operates the Narrows Project Powerplant (FERC 1403) in coordination with YCWA powerplants. PG&E also has water rights to 45,000 acre-feet (AF) of storage in Englebright Reservoir plus certain claimed riparian rights. Federal power licenses for these projects should be coordinated as to mitigation requirements and expiration dates. In addition, all holders of water rights and permits and users of downstream releases should be required to participate in meeting the temperature and flow recommendations contained herein.

Additional Studies

The following additional studies are needed to address concerns not addressed by past work or concerns brought to the forefront by past studies. The results should be used to refine the above recommendations.

1. Reservoir cold water availability studies of New Bullards Bar and Englebright reservoirs should be performed using reservoir temperature models to: (a) predict the effects of altered operations on water temperatures downstream; (b) characterize the reservoir elevations drawn upon by the intake structures; and (c) characterize the water temperature regime and volume of cold water present in these reservoirs available to the intake structures.
2. Lower Yuba River summer months (July through September) water temperature/discharge relationships should be modeled and the information included in appropriate analyses and used to refine the above recommended flow regime.
3. Habitat criteria studies for all life stages of American shad adequate for use in the Instream Flow Incremental Methodology (IFIM) model should be conducted. Data collection should be from observations of shad found in the Yuba River.
4. An IFIM study should be conducted for American shad to quantify the changes in weighted useable area for

No -
Not Valid.

various shad life stages over a broad range of flows. Key life stages are adult (migration and spawning), egg and larvae, and juvenile. An analysis of flow needs should be made and final recommendations to protect and enhance the American shad fishery of the Yuba River.

5. Attraction flows of short duration necessary to attract fall-run chinook salmon and steelhead trout into the lower Yuba River should be evaluated as to benefits for spawning populations.
6. Studies of Yuba River steelhead trout should be conducted to determine current population levels and establish population goals.
7. The recommended streamflow reduction schedule above may not provide the protection anticipated. Therefore, stranding studies should be conducted to evaluate potential impacts.

what about;

1. increased Delta exports
2. Commercial fishing
3. genetic loss of fish
4. Sacto River warming

FOREWORD

Many of California's resources and habitats have been lost due to development and demands for offstream uses of water. These losses are particularly acute for chinook salmon and steelhead trout. California Department of Fish and Game (DFG) and U.S. Fish and Wildlife studies show that 95% of California's historic salmon and steelhead habitat has been lost (Fisher 1979). In response to this habitat loss, the state's salmon and steelhead populations have dwindled to only 35-40% and 20%, respectively, of their historic numbers (Anonymous 1982; Fisher 1979).

The importance of these resources to the people of the State has been clearly affirmed by the California Governor, Legislature, Resources Agency, and Fish and Game Commission. Salmon and steelhead are recognized as valuable resources which have specific environmental requirements and limited ranges. In view of the losses these species have experienced, and their value to the State, the Salmon, Steelhead and Anadromous Fisheries Program Act was enacted in 1988. This Act is embodied in California Fish and Game Code Section 6900 et seq. These code sections state that, (a) it is the policy of the state to significantly increase the natural production of salmon and steelhead trout by the end of this century; (b) DFG shall develop a plan and a program that strives to double the current natural production of salmon and steelhead resources; (c) it is the policy of the state to recognize and encourage the participation of the public in privately and publicly funded mitigation, restoration, and enhancement programs in order to protect and increase naturally spawning salmon and steelhead trout resources; and (d) it is the policy of the state that existing natural salmon and steelhead trout habitat shall not be diminished further without offsetting the impacts of the lost habitat. In addition, the Legislature has declared that a substantial increase in requests to appropriate water has occurred, and that without due regard for the cumulative effects on streamflows of these requests, serious effects on fish and wildlife resources dependent upon these watercourses could occur. Thus, the Legislature directed the DFG (Public Resources Code Section 10000 et seq.) to prepare proposed streamflow requirements for specific streams.

The Resources Agency has developed a set of long range goals to aid in the restoration of salmon and steelhead trout resources and habitats (Anonymous 1982). These goals include increasing salmon and steelhead spawning populations by 300,000 fish, increasing the fishery catch by 600,000 fish, and reestablishing 500 mi of historic spawning and nursery areas.

It is the Fish and Game Commissions's policy to provide vigorous and healthy salmon and steelhead populations. The policy emphasizes maintaining adequate breeding stocks, suitable spawning

areas, and natural rearing areas. Habitat maintenance, restoration, and improvement are emphasized.

In view of the above policies, mandates, and clear need to strive to maintain existing salmon, steelhead, and other resources and habitats, and to restore these resources and habitats whenever possible, DFG implemented an investigation to assess the aquatic needs of anadromous resources within the Yuba River. This report presents the results of that investigation and resultant management recommendations.

-xx-

Same as in -
major Delta problems,
yet river "holding its own,"
excess fishing pressure

INTRODUCTION

The Yuba River originates on the west slope of the Sierra Nevada range and flows into the Feather River near Marysville, California, and thence to the Sacramento River. The Yuba River is considered a significant source of naturally spawned chinook salmon and steelhead and was known for its outstanding American shad fishery. During the 1970's and 1980's, the river did not achieve increased population trends that were projected to occur for chinook salmon and American shad following the completion of the New Bullards Bar Dam. Currently, fall-run chinook salmon spawning runs average 13,050 fish annually, far below the 38,000 fish anticipated. Although little data are available, steelhead populations may have increased following completion of the New Bullards Bar Dam in the late 1960's. Further, the American shad fishery has been almost eliminated. Since the turn of the century, water development projects and diversions have significantly adversely affected the river and its fisheries by modifying the timing of natural flows, reducing flows during critical periods, and altering spring, summer, and fall stream temperatures. These factors affect salmon and steelhead spawning, growth, and outmigration, and shad attraction, passage, and spawning activities.

In view of the value of the river's fishery resources, habitat losses, and demands to divert additional water offstream, DFG initiated a 3-year study in 1986 to identify problems and fisheries management needs for chinook salmon, steelhead trout, and American shad on the lower Yuba River between Englebright Dam and the Feather River. These studies included evaluating the streamflow, temperature, and aquatic habitat relationships, water quality conditions, fish population parameters, fish passage, riparian vegetation, and impacts of diversions on the fishery resources and their habitats. This report presents the results of these investigations, a management plan, and recommendations for the protection of the river and its fishery resources. Due to their sport and commercial fishery value, chinook salmon are considered the primary species of importance when developing the management plan.

Beak Consultants, Incorporated, Sacramento, California collected the data for this investigation, and DFG prepared the fishery management plan. Segments of Beak Consultant's reports to DFG are included in this report.

DESCRIPTION OF STUDY AREA

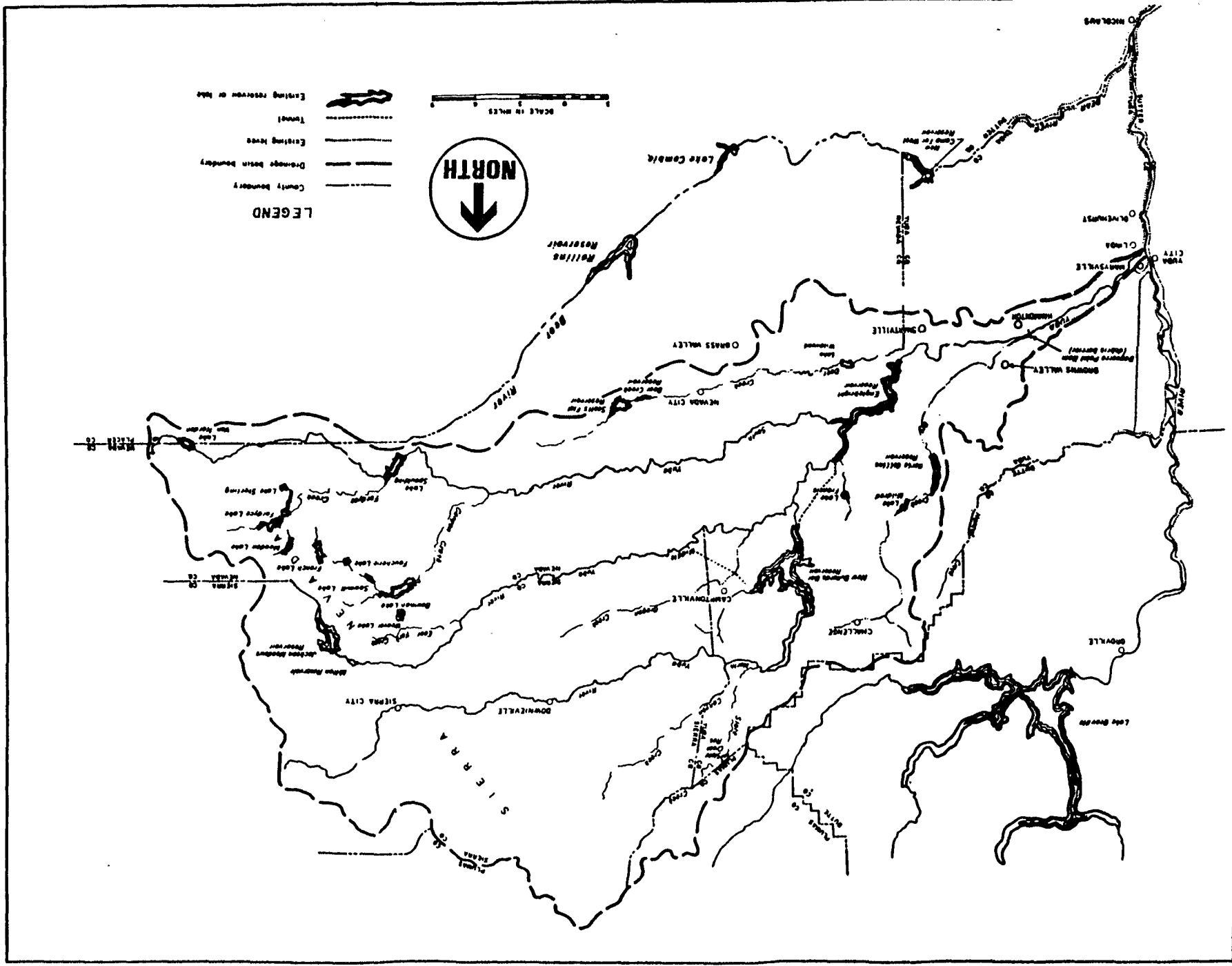
General Setting and Stream Description

*Below
As Basin*
The Yuba River system is located within the Central Valley of California, draining 1,339 sq mi of the western slope of the Sierra Nevada in Sierra, Placer, Yuba and Nevada counties (Figure 1). A component of the Sacramento River system, the Yuba River is a tributary of the Feather River, which in turn feeds into the Sacramento River. The lower Yuba River study area covered in this report extends approximately 24 mi from Englebright Dam (a hydroelectric generating and water storage facility) downstream to the confluence with the Feather River at Marysville, California (Figure 2). The study area is characterized by distinct reaches exhibiting relatively large differences in gradient, hydraulic conditions, channel morphology, and geology.

The river flows westerly from Englebright Dam, and descends an average of 13 ft/mi (0.27% gradient) from elevation 282 ft above mean sea level (MSL) to 120 ft MSL at Daguerre Point Dam, 12.5 mi downstream (Figure 2). The 11.5 mi of river from Daguerre Point Dam to Marysville has an average drop of 6.5 ft/mi (0.13% gradient). The streambed elevation at Marysville is 45 ft MSL.

Most of the water from Englebright Dam is released through the Narrows 1 and Narrows 2 powerhouses for hydroelectric power generation. Consequently, the 0.2 mi of river between the dam and powerhouses normally has standing water, except when the reservoir is spilling. The 0.7 mi of river downstream of the Narrows 1 and 2 powerhouses to the mouth of Deer Creek is characterized by steep rock walls, long deep pools, and short rapids. Below this area, the river cuts through 1.3 mi of sheer rock gorge called the Narrows, and the river consists of a single large, deep, boulder-strewn pool.

At the downstream end of the Narrows, the river canyon opens into a wide flood plain where large quantities of hydraulic mining debris remain from past gold mining operations (Figure 2). This 18.5-mi section is typified as open valley-plain. Daguerre Point Dam is located 12.5 mi downstream from Englebright Dam and is the major point of water diversion on the lower river. The open valley-plain continues 7.8 mi below Daguerre Point Dam to beyond the downstream terminus of the Yuba Goldfield. This 18.5-mi section is composed primarily of alternating pools, runs, and riffles with a gravel and cobble substrate and, by virtue of the quality and size of the substrate, contains the majority of the quality chinook salmon spawning habitat found in the lower Yuba River.





The remaining section of the lower Yuba River extends approximately 3.5 mi to the confluence with the Feather River (Figure 2). This section of river is bordered by levees and is subject to the backwater influence of the Feather River.

The lower Yuba River has two significant tributaries, Deer and Dry creeks. Deer Creek enters the Yuba River about 1.2 mi downstream of Englebright Dam. Falls impassable to migrating salmon are located about 500 ft up Deer Creek. Records indicate a few steelhead are able to pass the falls during some years. Dry Creek enters the river about 10.3 mi downstream of Englebright Dam. Flow in Dry Creek is regulated by the operation of Merle Collins Reservoir. Records indicate Dry Creek has a self-sustaining population of chinook salmon estimated to be 500 fish during 1983 (Preston 1986). It is believed steelhead trout utilize Dry Creek as well.

Plant communities along the lower Yuba River are a combination of remnant Central Valley riparian forests and foothill oak/pine woodlands, grasslands, and orchards. Much of the immediate river bank includes relatively bare regions denuded by hydraulic mining, gravel mining, and urbanization. Native grasslands and oak savannahs can be found further from the stream channel. Most of the original plant communities along the lower Yuba River have been converted to agricultural use, although fragments of the riparian woodlands still exist along the stream channel.

The climate in the vicinity of the lower Yuba River is of the hot savannah type (hot, dry summers, and cool, mild winters). U.S. Department of Commerce (1972) records for Marysville indicate mean monthly temperatures ranging from a low of 46.8°F in January to a high of 78.8°F in July. Most rainfall (85%) occurs between October and March. The average annual rainfall is 20.6 in at Marysville.

History of Development of Yuba River Basin

— GOOD HISTORY

The discovery of gold in the Yuba River in June 1848 attracted thousands of miners to the area. Hydraulic mining techniques were used to process an estimated 684,000,000 cubic yards of gravel and debris between 1849 and 1909 (Gilbert 1917). Most of this material was washed into the Yuba River and its tributaries causing extensive siltation in the river and on agricultural land along the lower Yuba River, and sedimentation and near-blockage of the Sacramento River. Agricultural and other interests responded by filing legal actions, and in 1884 a permanent injunction prohibited hydraulic mines from using the streams as mine dumps. Following 1884, most hydraulic gold mining was discontinued.

The California Debris Commission, an element of the U.S. Army Corps of Engineers (USACOE), was created by the United States Congress (Caminetti Act) in 1893. The commission's function was to serve as a regulatory agency to permit resumption of hydraulic mining under conditions that would prevent debris from entering

navigable waters or otherwise cause damage (USACOE 1977). In addition to its regulatory functions, the Commission was to act as a construction agency. The Commission constructed small dams on the Yuba River to reduce the downstream movement of mining debris. These impoundments limited the upstream migrations of anadromous fishes and ultimately contributed to the reduction of spawning populations in the Yuba River.

Barrier No. 1 Debris Dam was constructed in 1904-1905 about 4.5 mi upstream from the present Daguerre Point Dam (Figure 2). This dam completely blocked upstream movement of anadromous fish until 1907 when it was destroyed by floods (Wooster and Wickwire 1970).

Daguerre Point Dam was completed in 1906, and diversion of the river over the dam was completed in 1910. The dam is located approximately 12.5 mi downstream from Englebright Dam (Figure 2). It included two fish ladders, one designed for high and one for low water use. However, the ladders were ineffective, and the dam limited upstream spawning migrations except during periods of very high water (Wooster and Wickwire 1970). The fish ladders were destroyed by floods in 1927-1928, and fish passage facilities were not replaced until 10 years later. A new fish ladder was installed in 1938 but was used by few salmon because of its poor design. Consequently, only a portion of the spawning habitat upstream of Daguerre Point Dam was used from 1941 to 1950. New fish ladders were installed at the Daguerre Point Dam in 1950. These ladders were generally effective and allowed salmonid passage. Daguerre Point Dam was damaged by floods in February 1963, and repair of damage to the dam and fishway was completed in December 1964. In late December 1964, a portion of the bank and fishway was washed out by another flood and repair was completed in October 1965.

SCOE *
Construction of the Old Bullards Bar Dam by the Pacific Gas and Electric Company (PG&E) on the North Fork Yuba River began in 1921. Englebright Dam was constructed by the USACOE farther downstream in 1941 for sediment and flood control and completely blocked spawning runs of fish in upper portions of the mainstem Yuba River and its tributaries.

Flooding of Marysville and Yuba City in 1950 and 1955 resulted in the formation of the Yuba County Water Agency (YCWA) and development of plans for a new flood-control, water supply, and power-generating dam. The resulting structure, New Bullards Bar Dam, was completed in 1969. This dam contains multiple-level water outlets designed to control the temperature of downstream discharges.

Large quantities of water are diverted from the Yuba River for use in the Browns Valley, Hallwood-Cordua, South Yuba, and Brophy Irrigation districts during late spring, summer, and early fall months. The largest diversions occur at and just above Daguerre Point Dam (Figure 2). Pumps are used to divert additional

irrigation water between Daguerre Point Dam and the confluence of the Yuba and Feather rivers.

The impacts of development activities on the Yuba River have been severe. The combined effects of hydraulic mining, dredging, dams, and irrigation diversions have changed the character and natural resources of the river. The issue of instream flow needs to protect aquatic resources in the Yuba River has been the subject of debate since 1944 (Rich et al. 1944).

Fish Resources

Twenty-eight species of resident and anadromous fishes occur in the Yuba River (Table 1). Four anadromous species, fall- and spring-run chinook salmon, steelhead trout, American shad, and striped bass are of primary interest.

Fall-Run Chinook Salmon

Fall-run chinook salmon are the largest and most important anadromous fish in the lower Yuba River. Because of their size and food quality, they are highly prized by both commercial and sport fishermen. The Sacramento River system has historically been an important spawning area for this species. In the past the Yuba River supported up to 15% of the annual run of fall chinook in the Sacramento River system. Run sizes in the Yuba have varied over the period of record (1953-1989), from 1,000 (1957) to 39,000 (1982) fish (Table 2). Approximately 60% of these salmon spawn between Daguerre Point Dam and the Highway 20 Bridge. 22

During planning for the development of the Yuba River Basin in the late 1950s and early 1960s, projections were made of the expected benefits to the Yuba River fishery from construction of New Bullards Bar Dam and Reservoir. The DFG projected that increased streamflow and better control over water temperatures would result in improving the average fall chinook salmon run to over 38,000 fish (Wooster 1963; DFG 1965a). The maximum run was expected to exceed 80,000 fish (Wooster and Wickwire 1970). However, since impoundment of New Bullards Bar Reservoir in 1969, the average fall chinook salmon run has not improved. The salmon run for the 16-year period (1953-1968) prior to impoundment of New Bullards Bar Reservoir averaged 13,800 spawners. For the 21-year post-impoundment period (1969-1989), the fall-run averaged 13,050 fish (Table 2). High water temperatures and low flows during critical life stages are believed to limit chinook salmon production after project construction. 1969 not in proper period. See p. 45 1969 considered pre-impoundment there. where's proof run pre- & post Bullards habits

Fall-run chinook salmon typically begin spawning migration in the Yuba River in late September and may extend through January (Figure 3). Most spawning migration occurs in October and November. Low river discharge and high water temperatures in October may delay migration and spawning (Wooster and Wickwire 1970). Spawning normally occurs shortly after migration, primarily in October through January and peaks during November and

Very little spawning in early October.

Table 1. Common and scientific names of fishes occurring in the Yuba River above Marysville, California.*,+

Petromyzontidae	
Pacific lamprey	<u>Lampetra tridentatus</u>
Acipenseridae	
Green sturgeon	<u>Acipenser medirostris</u>
White sturgeon	<u>Acipenser transmontanus</u>
Clupeidae	
American shad	<u>Alosa sapidissima</u>
Salmonidae	
Chinook salmon	<u>Oncorhynchus tshawytscha</u>
Rainbow trout	<u>Oncorhynchus mykiss**</u>
(resident and anadromous)	
Cyprinidae	
Carp	<u>Cyprinus carpio</u>
California roach	<u>Hesperoleucus symmetricus</u>
Hardhead	<u>Mylopharodon conocephalus</u>
Golden shiner	<u>Notemigonus crysoleucas</u>
Sacramento squawfish	<u>Ptychocheilus grandis</u>
Speckled dace	<u>Rhinichthys osculus</u>
Catostomidae	
Sacramento sucker	<u>Catostomus occidentalis</u>
Ictaluridae	
White catfish	<u>Ictalurus catus</u>
Brown bullhead	<u>Ictalurus nebulosus</u>
Channel catfish	<u>Ictalurus punctatus</u>
Poeciliidae	
Mosquitofish	<u>Gambusia affinis</u>
Gasterosteidae	
Threespine stickleback	<u>Gasterosteus aculeatus</u>
Percichthyidae	
Striped bass	<u>Morone saxatilis</u>
Centrarchidae	
Green sunfish	<u>Lepomis cyanellus</u>
Warmouth	<u>Lepomis gulosus</u>
Bluegill	<u>Lepomis macrochirus</u>
Smallmouth bass	<u>Micropterus dolomieu</u>
Largemouth bass	<u>Micropterus salmoides</u>
White crappie	<u>Pomoxis annularis</u>
Black crappie	<u>Pomoxis nigromaculatus</u>
Percidae	
Loggerhead	<u>Percina caprodes</u>
Cottidae	
Riffle sculpin	<u>Cottus gulosus</u>
<u>Embiotacidae</u>	

Tule perch

Hysterothorax traski

* From Beak (1976).

+ Common and scientific names from Special Pub. No. 12, American Fisheries Society (1980).

** Taxonomic change according to Kendall (1988).

Table 2. Estimated fall-chinook salmon runs in the Yuba River, California, 1953-1989.*

Year	Number	Year	Number	Year	Number
1953	6,000	1966	8,000	1979	12,000
1954	5,000	1967	24,000	1980	13,000
1955	2,000	1968	7,000	1981	13,000
1956	5,000	1969	5,000	1982	39,000
1957	1,000	1970	14,000	1983	14,000
1958	8,000	1971	6,000	1984	9,665
1959	10,000	1972	9,000	1985	13,041
1960	20,000	1973	24,000	1986	19,558
1961	9,000	1974	18,000	1987	18,510
1962	34,000	1975	5,880	1988	10,760
1963	37,000	1976	3,800	1989	9,840
1964	35,000	1977	9,000		
1965	10,000	1978	7,000		

* Source: Years 1953-1972, Taylor (1974); years 1973-1982, Reavis (1984); year 1983, Reavis (1986); years 1984-1987, DFG unpublished data; and years 1988 and 1989, subject to revision. *why*

early December. Eggs incubate in the gravel into February, followed by hatching and emergence of fry into March. Fry may emigrate within a few weeks of emergence or may rear to the juvenile stage until June when they emigrate (Moyle 1976). Exceptions do occur, however, and juveniles have been captured in seine hauls in September at Parks Bar (Fred Meyer, DFG - Region 2, per. comm. 1989). Juveniles tend to emigrate at night near the water surface (Raleigh et al. 1986).

Spring-Run Chinook Salmon

In most California rivers that support this stock, summer is spent in deep pools where water temperatures seldom exceed 69.8-77.0°F (Moyle 1976). Studies by USFWS staff on the Trinity River, California, suggest spring-run chinook select water temperatures less than 60°F (R. Brown, USFWS, Lewiston, CA, per. comm. 1990). This period of summer holding prior to spawning is a major difference in the life history of spring- and fall-run stocks.

A small spring-run chinook population originally occurred in the Yuba River. However, the run virtually disappeared by 1959 (Fry 1961), presumably due to diversion and hydraulic developments on the river. A remnant spring-run persists in the lower Yuba River and is being maintained by fish produced in the river, fish straying from the Feather River (Fred Meyer, DFG-Region 2, per. comm. 1989), *or* from infrequent stocking of hatchery-reared fish by the DFG (Table 3).

In the Sacramento-San Joaquin system spring-run chinook historically migrated into the upper reaches of streams in spring, spent the summer holding in deep pools, and spawned in late fall

(Moyle 1976). However, dams have blocked access to upstream areas, and stocks have declined. The spring-run has persisted in some rivers, apparently by adapting to use of available habitat. Little life history information is available for this stock in the Yuba.

Figure 3. Life history periodicity for fall- and spring-run chinook salmon, steelhead trout, and American shad in the lower Yuba River, California.*

Fall-Run Chinook Salmon													
Life Stage	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Spawning migration	X								X	X	X	X	
Spawning	X									X	X	X	
Egg incubation	X	X								X	X	X	
Emergence	X	X	X	(X)								X	
Fry rearing/emigration	X	X	X	(X)								X	
Juv rearing/emigration				X	X	X							

length data on
P550 show fish
4 2 inches present in
April - these are fry.

Spring-Run Chinook Salmon													
Life Stage	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Spawning migration			X	X	X	X	X						
Summer holding						X	X	X					
Spawning									X	X	X		
Egg incubation									X	X	X	X	
Emergence	X										X	X	
Fry rearing/emigration	X	X	X									X	
Juv rearing/emigration			X	X	X	X							

Steelhead Trout													
Life Stage	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Spawning migration	X	X	X					X	X	X	X	X	
Spawning	X	X	X	X									
Egg incubation	X	X	X	X	X								
Emergence		X	X	X	X	X							
Fry & juvenile rearing	X	X	X	X	X	X	X	X	X	X	X	X	
Emigration			X	X	X	X							

American Shad													
Life Stage	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Spawning migration				(X)	X	X							
Spawning				(X)	X	X	X						
Egg incubation & hatching					X	X	X						
Rearing & emigration					X	X	X	X	X	X	X		

Most rearing, emigration in Feather and Sac R

No proof of this.

* The life history information is based on review of the literature and DFG fishery biologists familiar with the anadromous fish species of the lower Yuba River. The periodicities shown are believed to represent the time of occurrence of an unknown but large majority of a life stage population, consequently, exceptions may commonly occur.

Table 3. Stocking of hatchery-reared spring-run chinook salmon and steelhead trout in the lower Yuba River, California, from 1970 through 1980.*

Year	Species+	Life stage	Number
1970	Steelhead	Subcatchables	77,927
1971	Steelhead	Subcatchables	217,378
1972	Steelhead	Yearlings	48,760
1973	Steelhead	Fingerlings	176,670
1975	Steelhead	Yearlings	50,903
1976	Steelhead	Yearlings	53,460
1977	Steelhead	Yearlings	49,867
1977	Steelhead	Subcatchables	54,531
1978	Steelhead	Yearlings	51,580
1979	Steelhead	Yearlings	27,270
1980	Chinook	Fingerlings	21,460
1980	Chinook	Yearlings	15,925

* Source: DFG unpublished data.

+ Steelhead trout from Coleman National Hatchery; chinook are spring-run chinook salmon from Feather River Hatchery.

Spring-run chinook migrate into the lower Yuba from March through July, although some migration may occur in August. The majority of the run occurs in May and June (Moyle 1976).

was previously occurred
These fish apparently spend the summer in the cooler water just below the Narrows 1 and 2 powerhouses or further downstream in the Narrows (Fred Meyer, DFG-Region 2, per. comm. 1989). Spawning may begin in August but appears to occur mainly in September, October, and perhaps into November (Moyle 1976). Recent information suggests that spawning primarily occurs in the Yuba from late September through early November. The DFG conducted a spawning survey from early October to early November 1986 when about 20 pairs of chinook salmon were observed spawning just below the Narrows Powerhouse (Fred Meyer, DFG - Region 2, per. comm. 1989). It was concluded that these were spring-run chinook since they could not have passed high gradient riffles downstream during low fall discharge, but could have done so during high spring flows.

Egg incubation probably occurs into December, and fry emergence begins in November and extends through January. Fry may emigrate within a few weeks of emergence or remain to rear to the juvenile stage and emigrate as late as June.

Steelhead Trout

Wooster and Wickwire (1970) estimated about 200 steelhead trout spawned in the river annually, and that there was a potential for about 2,000 spawners after completion of New Bullards Bar Reservoir. While no definitive population estimates exist, limited information suggests lower Yuba River winter-run steelhead trout populations may have increased (DFG 1984). The life history periodicity for steelhead in the lower Yuba River is summarized in

-11-

It previously said that the lower Yuba River supports a small winter-run steelhead population estimated to number about 2,000 fish.

as young
spawning
season
was 4

Figure 3. Steelhead migrate from the ocean to their natal streams to spawn in the fall and winter (Raleigh et al. 1984; Moyle 1976). In the lower Yuba River, the spawning migration begins as early as August, peaks in October and February, and may extend through March (DFG 1984; Painter et al. 1977). A run of half-pounder steelhead is known to occur principally from late June through the summer, fall, and winter months (R. DeHaven, USFWS, Sacramento, CA, per. comm. 1990). Steelhead spawn in the late winter and early spring months (January through April). Egg incubation and emergence from the gravel extends into May and early June, respectively. Fry remain in the river to rear to juveniles for 1 to 3 years prior to smolting and emigration to the ocean. Emigration generally occurs from March into June. Steelhead mature after 1 to 2 years in salt water and return to their natal stream to spawn. was 4

Environmental factors influencing the steelhead trout population in the lower Yuba River are similar to those affecting chinook salmon. However, unlike chinook salmon, steelhead typically rear in the river for 1 or more years. Thus, high water temperatures and low flows during critical life stages may be affecting steelhead to a greater degree than chinook salmon.

DFG's Yuba River steelhead trout management activities have consisted primarily of hatchery stocking. From 1970 to 1979, DFG annually stocked between 27,270 and 217,378 hatchery-reared (Coleman National Hatchery) fingerlings, yearlings, or subcatchables in the river (Table 3). The future management of this species would benefit from studies that determine adult population levels and establish population goals. The stock is currently managed as a naturally sustained population. but not wild

Areas in the lower Yuba River that are actively used as spawning and rearing habitat by steelhead trout have not been determined.

American Shad

The introduction of American shad into the Sacramento River in 1871 was highly successful. The shad population expanded rapidly, and 8 years later, a commercial fishery developed (Moyle 1976). The fishery peaked in 1917 when about 5.7 million pounds were landed. From 1918 to 1945 the annual catch ranged from 0.8 to 4.1 million pounds. The catch declined after 1945, and between 1945 and 1957, the catch exceeded a million pounds just once (Painter et al. 1979). The commercial fishery was eliminated in 1957 to facilitate development of a sport fishery.

There is no clear record of when the shad sport fishery began in California (Painter et al. 1979). Angling occurred in the 1930's and 1940's, but enthusiasm for the sport did not develop until the 1950's. Thereafter, the sport grew to an estimated 100,000 angler days in the mid-1960's for the Sacramento system (DFG 1965b). However, the sport fishery has declined to about 35,000 to 55,000 angler days per year in 1976-1978 (Meinz 1981). The more popular

angling areas are located on the Sacramento, American, Feather, and Yuba rivers.

The lower Yuba River supports a seasonal shad sport fishery. The fishery generally is confined to the area between Daguerre Point Dam and the confluence with the Feather River from late April into July (Wooster and Wickwire 1970; Mainz 1981). Previous studies indicate the shad fishery has declined on the Yuba River. Wooster and Wickwire (1970) estimated that Yuba River shad anglers spent 6,400 angler-days annually, while Mainz (1981) estimated from 150 to 3,300 angler-days annually during the 1976-1978 period. Virtually no shad fishery existed on the Yuba River during 1987 and 1988 (Fred Meyer, DFG-Region 2, per. comm. 1989).

Daguerre Point Dam is believed to affect shad spawning movements. The dam is equipped with two conventional pool and jump type fishways, but few shad use these facilities. However, in 1969 several hundred shad were able to pass the dam and were observed upstream to Parks Bar. In 1968 the shad run was estimated at 30,000 to 40,000 spawners, and in 1969 at 40,000 spawners (USACOE 1977).

American shad rear to sexual maturity in the sea and then migrate to their natal river to spawn. Within the Sacramento River drainage, the relative magnitude of tributary discharge to that in main stem rivers appears to determine the distribution of American shad spawning for the first time (virgin) (Painter et al. 1979). Preliminary results of investigations to date suggest that to maintain a historic distribution of adult virgin shad to the Yuba River, the May-June flow of the Yuba should not be less than 33% of the Feather River discharge and the Feather River should not be less than 34% of the Sacramento River discharge (Painter et al. 1979). Studies of the Yuba River American shad sport fishery in 1976-1978 indicate as the April-June 3-month average flow at Marysville during 1976 and 1977 increased from less than 300 cfs to greater than 3,000 cfs during 1978, the catch rate increased from 0.54 and 0.04 to 1.06, respectively (Mainz 1981; Appendix I).

*check
The peak of upstream shad migration through the western Sacramento-San Joaquin Delta occurs during March, April, and May (Painter et al. 1979). Migration into the Yuba River is believed to occur during April through June (Figure 3). Shad spawn only in fresh water (Leim 1924; Massmann 1952; Walburg 1960). Spawning typically occurs from late April through July on the Feather River (Painter et al. 1977). Studies conducted from 1972 through 1974 on the Yuba River indicate that Yuba River shad spawn during this same time period (DFG 1975). This period corresponds to the May through mid-July period cited by Wooster and Wickwire (1970) from studies conducted in 1963. (was "DFG unpublished data")

Shad spawn in schools of wildly swimming, thrashing fish in the main channels of rivers over sand to gravel substrate in depths of 3 to 30 ft or more (Painter et al. 1979; Moyle 1976). Spawning

occurs near the water surface, and can occur at any time of day, although spawning is most frequent at night. Females broadcast their eggs and one or more males fertilize the eggs. Fish spawn repeatedly and females release a total of 30,000 to 300,000 eggs depending on age and size (Moyle 1976). Spawning intensity apparently is related to water temperature. During studies of American shad in the Feather and Yuba rivers from 1971 through 1974, spawning intensity (as measured by egg abundance) increased or decreased in the direction of the temperature change when day to day water temperatures changed greater than $\pm 3^{\circ}\text{F}$ (DFG 1975). A similar response was noted in the angler catch rate (R.E. Painter, DFG, per. comm. 1989). The majority of fish die after spawning, but some survive to spawn the next year. Post-spawning mortality increases in warmer water, particularly at 68.0°F and higher (Moyle 1976). was "DFG unpublished data" who is Moyle quoting

Shad eggs are semibuoyant, non-adhesive, and drift downstream with the current until they gradually sink to the bottom (Painter et al. 1979; Moyle 1976). Incubation takes 3 to 6 days at about 59.0 to 64.4°F . Incubation is faster in warmer water, but mortality increases.

Newly hatched shad larvae are about 0.35 to 0.4 in total length (TL) (Painter et al. 1979; Moyle 1976). Within a month, length triples, and by the time they enter salt water, larvae are 2 to 7.2 in TL. Newly hatched larvae may be rapidly transported downstream by currents due to their small size. Studies conducted during 1976-1978 to identify shad nursery areas in the Sacramento River system and Sacramento-San Joaquin Delta revealed that the Sacramento River above Knights Landing, the Feather River above Yuba City, and the entire American and Yuba rivers were not season-long nursery areas for juvenile shad (Meinz 1979). This is consistent with Stevens' (1966) conclusion that the seaward migration of juvenile shad through the Delta starts in late June and extends through November.

Juvenile shad spend several weeks to several months in the Delta, progressively moving closer to salt water. Little is known of the life history of American shad in salt water along the Pacific coast (Moyle 1976).

Striped Bass

Striped bass are native to streams and bays of the Atlantic coast from the St. Lawrence River to Florida, and along the Gulf of Mexico from Louisiana to Florida (Moyle 1976). They were introduced into the Sacramento-San Joaquin Estuary in 1879 and 1882. The species rapidly established itself, and by 1888 it supported a commercial fishery which produced landings in excess of 1.2 million pounds (Skinner 1962). The main population centers are the Sacramento-San Joaquin Estuary and river system, but smaller populations have been established in rivers and estuaries of the Russian and Klamath rivers in California, and the Coos, Umpqua, and Coquille rivers in Oregon.

How often:
only seasonally?

was "do not"

Striped bass occur in the lower Yuba River below Daguerre Point Dam and are not known to migrate beyond the dam (Wooster and Wickwire 1970). Adult and juvenile fish move into the river in May and June. Movement into the river corresponds to the spawning period (Moyle 1976). However, striped bass eggs and larvae have not been recovered in the Yuba River (Wooster and Wickwire 1970; DFG 1975). Bass probably use the river for feeding rather than spawning.

Striped bass are taken incidentally by anglers fishing for other species in the Yuba River (Wooster and Wickwire 1970). On occasion, a substantial fishery was noted in the Feather River near Marysville (Painter et al. 1977).

HYDROLOGY

The Yuba River, a major tributary of the Sacramento River, drains a 1,339-sq mi watershed originating in the higher elevations of the west slope of the Sierra Nevada. The Yuba River is drained by the North Fork Yuba River, Middle Fork Yuba River, and the South Fork Yuba River (Figure 1). The three tributaries join to form the main Yuba River upstream of the USACOE Englebright Dam, where the terrain changes to foothills. New Bullards Bar Reservoir, on the North Fork Yuba River, is the largest impoundment in the drainage and the principle storage reservoir regulating inflows to Englebright Reservoir. There are numerous other storage and diversion facilities in the drainage, and flow is highly impacted as a result of these projects for water storage, diversion, and hydroelectric power generation (Figure 4).

Rainfall and snowmelt are the major sources of water supply in the watershed. Runoff from snowmelt produces a large portion of the total seasonal water supply. Most of the precipitation in the basin occurs during the period November through March, with maximum storm intensities typically occurring in January, February, and March. Winter precipitation at high elevations usually occurs as snow. Annual precipitation ranges from a low of 30 in in the western part of the watershed in the vicinity of Englebright Dam, to a high of about 80 in in the northern and southeastern portions of the drainage area (PG&E 1989). In a typical year, the April 1 accumulation of snow in the mountains is equivalent to 40.3 in of water at the 6,500-ft elevation and 48.9 in at the 7,200-ft elevation. Snowmelt occurs in the late spring and early summer months, and streamflow are usually at their lowest in July to October.

There are several diversions on the lower Yuba River in the vicinity of Daguerre Point Dam (Figure 2). The primary consumptive use of these diversions is agricultural irrigation, which accounts for more than 90% of water use. The YCWA is the most significant holder of water rights with permits or licenses for 2,080,000 acre-feet (AF) per year. YCWA has contractual agreements to supply water to meet water rights and sales contracts primarily with the Hallwood Irrigation Company (78,000 AF), Cordua Irrigation District (82,000 AF), Ramirez Water District (13,900 AF), Brophy Water District (35,330 AF), South Yuba Water District (22,100 AF), and Browns Valley Irrigation District (25,687 AF). Flows diverted by these agencies can reach a maximum of 1,085 cfs. An additional 18,204 AF exists in miscellaneous riparian and active sales contracts.

Discharge (gaged near Marysville, water years 1944-1987) through the study area averages 2,600 cfs. However, flows historically ranged from a low of 10 cfs (July 1959) to more than 180,000 cfs (December 1964) (USGS 1981, 1986, and 1988). There is little summer accretion flow below Englebright Dam and virtually all of

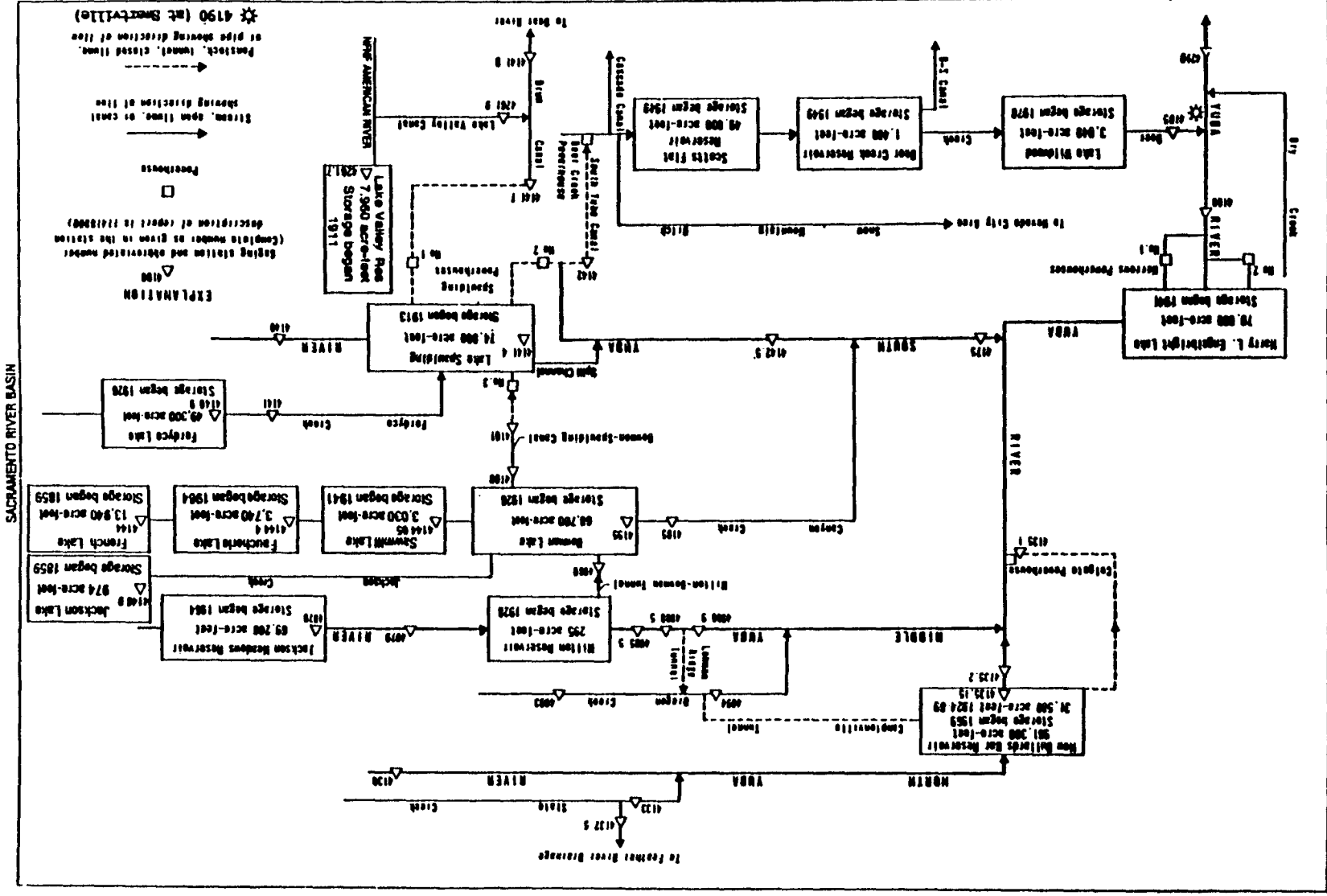


Figure 4. Schematic diagram showing diversions and storage in the Yuba River basin, California. Taken from USGS (1988).

this streamflow originates from Englebright Reservoir. The two major tributaries are Deer Creek and Dry Creek. Average annual discharge from Deer Creek is 130 cfs, based on 53 years of record 1935 to 1988 (USGS 1988). Peak discharges in Deer Creek occur during late fall and winter storm events. Extremes for the period of record are a maximum of 12,100 cfs (February 1986) and a minimum daily of 0.06 cfs (August 1977). Several reservoirs (Lake Wildwood, Deer Creek Reservoir, and Scotts Flat Reservoir) and diversion canals (Cascade Canal and D-S Canal) on upper Deer Creek normally limit spring, summer, and fall flows to less than 10 cfs.

Average annual discharge from Dry Creek is 77 cfs, based on 16 years of record 1964 to 1980 (USGS 1980). Extremes for the period of record are a maximum of 5,950 cfs (January 1969) and a minimum daily of 0.84 cfs (October 1977). Peak discharges occur during winter storm events. Flows are regulated by Lake Mildred, Merle Collins Reservoir, and some diversions for irrigation.

Annual and monthly streamflow patterns are essential components of any instream needs assessment on the lower Yuba River. These streamflow patterns were analyzed using 63 years of unimpaired flow provided by the California Department of Water Resources (DWR) and 20 years of streamflow data provided by USGS. Using these data, the annual and monthly water supply outflow characteristics below Englebright Reservoir were determined.

Annual Unimpaired Runoff

*one of these
+ affiliated
in Yuba A.*
Unimpaired flow represents the runoff from a basin that would have occurred had not the flow of water in the basin been altered with the construction of reservoirs and diversions.

An analysis of the estimated unimpaired flow at Smartville (below Englebright Dam for old USGS station 11419000 located below Deer Creek) for water years 1921-1983 was performed using data published by DWR (1987a) (Table 4). From the DWR estimates of unimpaired flow, the average annual outflow over the 63-year period is 2,332,730 AF (this value is rounded to 2,333,000 in Table 4). Further, for this period 1921-1983, outflow during 29 years (46% of the time) equaled or exceeded this average annual flow value. Thus, the average annual value is a good indicator of the long-term average water supply since a large number of data are available.

"Normal" hydrologic conditions are present when the estimated unimpaired runoff equals the long-term average (forecasted runoff is 100% of the long-term average). "Dry" hydrologic conditions exist when runoff is at some predetermined percentage less than normal or the long-term average. "Dry" hydrologic conditions are often defined as less than 50% of the unimpaired runoff for a series of water years, usually 50 years.

Table 4. Estimated unimpaired flow (acre-feet x 1,000) at Smartville (USGS gage 11419000), lower Yuba River, California. From DWR (1987a). Dry years less than 50% of the 63-year average are indicated by asterisk.

Water year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1921	43	280	329	421	280	473	414	498	315	64	30	22	3169
1922	25	31	113	122	318	261	421	869	650	104	36	22	2972
1923	27	57	296	165	113	159	432	459	221	84	33	28	2074
1924	33	24	55	40	127	62	137	78	17	6	9	14	602 *
1925	33	53	121	111	563	232	403	396	127	38	25	21	2123
1926	25	38	55	64	411	220	454	213	72	20	17	19	1608
1927	30	314	201	226	745	422	586	539	366	67	23	21	3540
1928	22	149	135	178	155	798	465	380	87	33	17	17	2436
1929	20	36	48	42	84	145	190	275	118	23	0	30	1011 *
1930	13	13	291	179	209	321	345	269	113	26	19	19	1817
1931	5	48	17	61	61	148	140	94	37	8	9	12	640 *
1932	26	36	166	147	196	278	347	533	300	46	26	13	2114
1933	16	16	27	40	35	142	217	284	239	36	12	15	1079 *
1934	22	27	97	128	150	234	172	86	37	15	7	13	988 *
1935	17	66	72	153	150	199	672	558	274	44	21	16	2242
1936	27	32	42	345	528	332	500	461	226	54	21	21	2589
1937	17	16	31	32	231	281	415	566	198	42	18	13	1860
1938	22	107	496	141	423	711	590	845	527	114	36	23	4035
1939	34	39	47	56	55	214	263	126	48	13	3	9	907 *
1940	22	21	32	392	577	723	495	403	129	29	18	19	2860
1941	25	69	256	374	504	425	421	645	251	117	27	23	3137
1942	24	70	370	497	512	238	535	554	426	108	40	31	3405
1943	29	135	283	587	308	631	502	358	189	56	34	21	3133
1944	29	31	42	64	143	213	215	421	162	37	22	18	1397
1945	22	107	149	105	466	203	319	450	196	50	26	20	2113
1946	36	117	492	260	146	257	407	445	149	47	25	17	2398
1947	31	96	101	54	184	301	263	179	90	27	20	17	1363
1948	55	52	41	209	68	128	509	509	323	65	34	16	2009
1949	22	38	62	42	77	245	412	408	111	31	19	19	1486
1950	14	31	38	237	331	309	461	469	227	47	24	30	2218
1951	69	677	794	411	378	286	360	365	112	30	33	25	3540
1952	41	102	315	325	481	356	692	929	582	221	45	30	4119
1953	43	32	127	570	143	214	383	403	410	133	51	45	2554
1954	31	65	63	155	238	385	491	323	96	34	18	19	1918
1955	17	40	107	100	82	123	182	388	181	35	16	15	1286
1956	17	40	1192	776	308	287	334	576	296	86	23	28	3963
1957	45	48	44	65	313	389	252	493	222	45	23	19	1958
1958	41	59	140	182	686	443	582	799	434	99	32	32	3529
1959	20	37	33	201	226	189	232	171	71	25	12	21	1238
1960	10	17	19	74	389	418	313	265	133	32	15	11	1696
1961	15	50	64	37	155	176	219	252	107	23	16	12	1126 *
1962	17	21	73	56	435	219	454	361	204	44	26	13	1923
1963	451	79	248	214	596	205	557	608	204	56	31	24	3273
1964	33	212	77	133	108	123	247	320	152	40	19	16	1480
1965	16	63	1341	678	240	198	502	442	264	72	41	26	3883
1966	25	91	76	123	99	227	402	282	58	20	10	11	1424
1967	16	129	282	393	260	420	299	657	603	177	44	20	3300
1968	26	30	69	143	442	275	243	222	78	21	18	6	1573
1969	28	89	130	964	377	278	522	768	388	42	66	17	3669
1970	31	39	386	1278	263	287	173	275	127	34	14	8	2915
1971	0	184	338	288	206	394	358	562	374	86	44	23	2857
1972	29	45	104	135	181	423	254	306	160	31	14	29	1711
1973	47	150	243	509	353	310	321	500	142	28	18	25	2646
1974	34	559	395	706	174	680	487	494	282	110	29	16	3966
1975	8	35	48	84	285	399	272	594	438	99	52	39	2353
1976	70	76	62	47	76	123	128	130	30	5	27	7	781 *
1977	11	26	3	35	17	34	60	82	37	11	3	6	325 *
1978	7	21	177	558	288	527	427	482	322	88	20	42	2959
1979	19	31	36	131	178	311	308	519	129	27	18	19	1726
1980	37	74	113	956	599	314	336	398	225	80	23	19	3174
1981	24	24	59	103	165	224	248	182	45	18	10	10	1112 *
1982	40	613	777	376	669	468	885	636	305	101	26	29	4925
1983	121	191	377	322	565	929	429	716	712	274	62	37	4735
Ave	35	97	203	263	288	316	375	427	225	58	25	20	2333

Pre New
Billards

3 yrs less than
any years in
1953-1970

Complete
hydrology

Monthly Runoff

Data were developed to illustrate monthly streamflow patterns in the lower Yuba River following completion of New Bullards Bar Dam. These data were derived from records obtained from USGS and compared to monthly unimpaired data from DWR (1987a) (Table 5, Figure 5).

The difference between the unimpaired and impaired monthly flow below Englebright can be attributed to the impacts of storage upstream of Englebright Dam, channel loss, evaporation, and diversion. For example, the impact of storage can be seen where impaired flows exceed unimpaired flows as a result of water stored during the wet period then released during the dry months of July, August, September, October, and November (Figure 5).

The difference between monthly impaired flows as measured below Englebright Dam and those near Marysville can be attributed to the increased size of the watershed downstream near Marysville as compared to the smaller drainage area at the station below Englebright Dam (1,339 and 1,108-sq mi, respectively) and the diversion of water near Daguerre Point Dam. Typically, the flows near Marysville exceed those below Englebright Dam during the wet months of December through March when diversions do not occur,

Table 5. Mean monthly flows for the lower Yuba River, California, from monthly estimates of unimpaired flow at USGS gage station 11419000 located at Smartville for water years 1921-1983, and from mean daily impaired flow records for water years 1969-1988 for USGS gage stations located below Englebright Dam (11418000) and near Marysville (11421000). *check year*

Month	Unimpaired flow		Impaired flow			
	At Smartville (cfs)	(AF)	Below Englebright (cfs)	(AF)	Near Marysville (cfs)	(AF)
Oct	569	35,000	1,397	85,899	1,251	76,922
Nov	1,627	96,790	1,777	105,740	1,700	101,159
Dec	3,309	203,440	2,706	166,388	2,862	175,980
Jan	4,285	263,490	3,887	239,006	4,513	277,498
Feb	5,180	287,700	4,051	224,984	4,976	276,357
Mar	5,147	316,490	3,434	211,152	4,249	261,265
Apr	6,310	375,460	2,920	173,755	3,148	187,322
May	6,936	426,510	2,580	158,640	2,216	136,259
Jun	3,774	224,570	2,259	134,422	1,803	107,288
Jul	949	58,380	1,762	108,343	1,280	78,705
Aug	400	24,600	1,896	116,582	1,471	90,450
Sep	341	20,290	1,662	98,897	1,489	88,603
Total		2,332,730		1,823,808		1,857,808

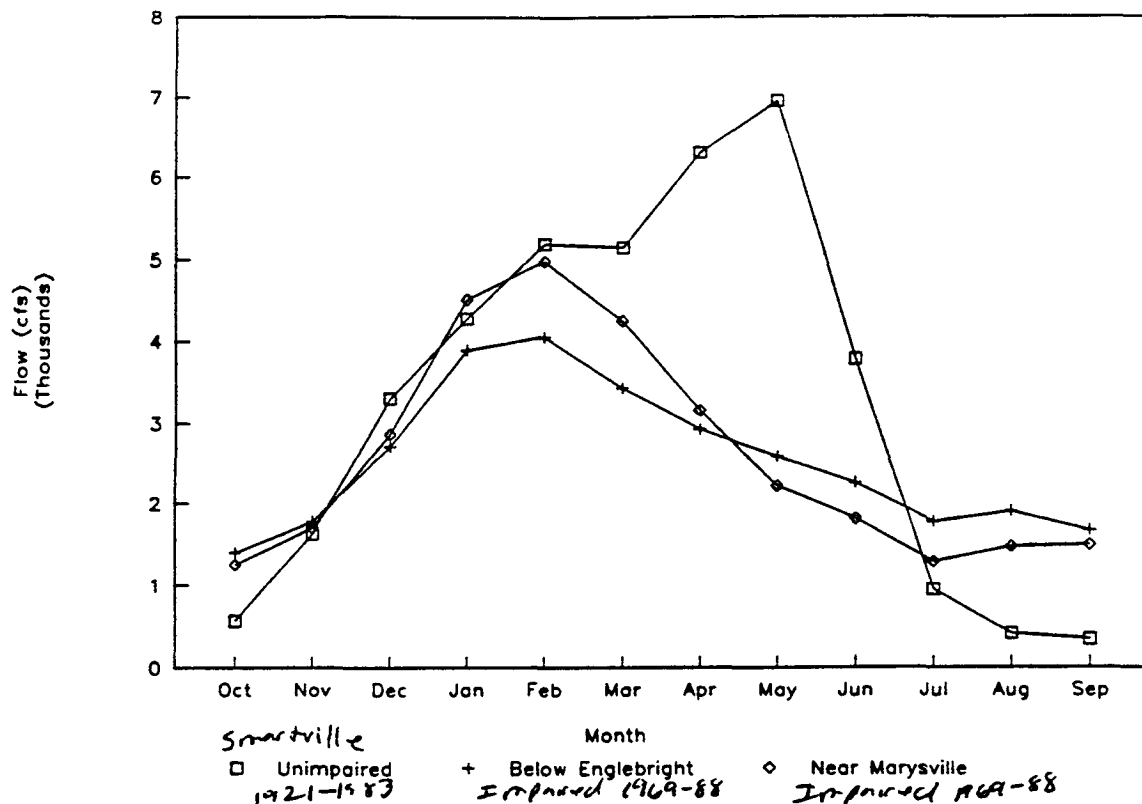


Figure 5. Comparison of mean monthly flows at selected USGS gage stations located at Smartville (gage 11419000, estimated unimpaired flows for water years 1921-1983), below Englebright Dam (gage 11418000, impaired flows for water years 1969-1988), and near Marysville (gage 11421000, impaired flows for water years 1969-1988), lower Yuba River, California.

inflow from Deer and Dry creeks is greatest, and runoff from the larger drainage area is greatest (Figure 5). Conversely, flows near Marysville are less than those measured below Englebright Dam during the months of greatest diversion, April through November.

Discussion

Below average water years present special problems. Sufficient water may not be available during dry years to fully meet instream and offstream needs. Thus, it is necessary to develop dry year criteria. For these investigations, "dry" hydrologic conditions are defined as less than 50% of the 50-year average unimpaired runoff of the Yuba River in acre-feet at Smartville for the current water year.

Assessment of the current water year runoff can be determined from DWR's forecast of the current water year unimpaired runoff for Central Valley streams which compares this forecast to the 50-year average. This report is published annually by DWR as the May 1.

*Not
Agency
to this*

Report of Water Conditions in California. The series of years used to compute the 50-year average varies, but generally includes the preceding 50 years immediately prior to the year of interest and is updated every 5 years. For example, DWR's May 1, 1985 forecast for the Yuba River at Smartville was based on data from water years 1931-1980 (DWR 1985), while for the May 1, 1987 forecast, the 50-year average was based upon data from water years 1936-1985 (DWR 1987b). The 50-year average values for the Yuba River (at Smartville) during these 2 years were 2,297,000 AF and 2,460,000 AF, respectively, closely resembling the 63-year average of 2,332,730 AF found in Table 4. Thus, for the water years 1985 and 1987, dry hydrologic conditions existed only for the 1987 water year when the forecasted annual runoff was 35% of the 50-year average or "normal".

*X
what
??*

Identification of the frequency of dry year occurrence during the 63-year period (1921-1983) of estimated unimpaired flows at Smartville contained in Table 4 is possible by applying this dry year criteria. This is appropriate since the 50-year averages cited for the 1985 and 1987 water years closely resemble the 63-year historical average. Doing so indicates 10 years can be classified as "dry" or less than 50% of the average annual unimpaired flow, while 53 years exceed the dry year status.

*Fish equal
, other
reflected
res in
critical
years*

During critically dry years when water availability is less, flows are often reduced according to a curtailment schedule. Thus, in the event a dry year is identified, reductions to fishery flows recommended by DFG and offstream diversions should be made on an equal percentage basis. Such reductions should be based on water available to permanent contracts existing on January 1, 1990. Offstream contractual obligations and diversions made after January 1, 1990 should be reduced to zero before reductions in fishery flows occur.

Conclusions

The flow pattern of the lower Yuba River below Englebright Dam has been altered due to projects for storage, diversion, and hydroelectric power generation. Estimates of unimpaired flow (without projects) indicate peak runoff typically occurs during March through June while existing impaired runoff peaks during the months of January through April.

Diversions out of the Yuba River basin upstream of and downstream of Englebright Reservoir have reduced the flow at Marysville.

For the 63-year period 1921-1983 of estimated unimpaired flows at Smartville, 10 years can be classified as "dry" and less than 50% of the average annual unimpaired flow, while 53 years exceed the dry year status.

The difference between the unimpaired and impaired monthly flow below Englebright can be attributed to the impacts of storage

upstream of Englebright Dam, channel loss, evaporation, and diversion. For example, the impact of storage can be seen where impaired flows exceed unimpaired flows as a result of water stored during the wet period, then released during the dry months of October, November, July, August, and September.

Typically, the flows near Marysville exceed those recorded below Englebright Dam during the wet months of December through March when diversions do not occur. During the period, inflow from Deer and Dry creeks is greatest. Conversely, flows near Marysville are less than those measured below Englebright Dam during the months of greatest diversion, April through November.

"Dry" hydrologic conditions are defined as less than 50% of the 50-year average unimpaired runoff of the Yuba River in acre-feet at Smartville for the current water year as published annually in the May 1, Report of Water Conditions in California by DWR. In the event a dry year is identified, reductions to fishery flows recommended by DFG and offstream diversions should be made on a equal percentage basis. Such reductions should be based on water available to permanent contracts existing on January 1, 1990. Post January 1, 1990 offstream contractual obligations and diversions should be reduced to zero before reductions in fishery flows occur.

Sampled by electrofishing Feb 9, 10, 11, 12 (1987)
May 4, 5, 6 (1987)

Sampled by Snorkeling

FISH COMMUNITY STUDIES

Management of the fish resources in the lower Yuba River requires understanding of the fish community composition and biology, interactions of anadromous and resident fishes, and the influence of abiotic and biotic conditions on fish abundance and distribution.

To meet these information needs, surveys were conducted to assess species composition, relative abundance and distribution, chinook salmon growth rates and condition, and predation on juvenile chinook salmon.

Fish Species Composition, Relative Abundance, and Distribution

Fish species composition, relative abundance, and distribution were assessed using two methods, electrofishing and direct under-water observation (snorkeling). Electrofishing was conducted by boat to obtain data on secretive species under-represented in snorkel surveys, and to obtain fish for length, weight and age measurements, as well as for analysis of stomach contents. Snorkel surveys were conducted primarily to characterize juvenile salmonid habitat use during spring in all habitats, including shallow near shore and riffle areas that were inaccessible to boat electrofishing.

Species Composition

9 sites total in 4 reaches

Nine sites were electrofished during February and seven of the nine sites during May 1987 (Figure 2). The two sites in river reach three were not sampled in May. The sampling sites were located within each of the four river reaches and were associated with the IFIM sites except in river reach two where alternative sites were selected. To insure adequate sampling coverage of a site, three electrofishing runs (left river bank, center channel, right river bank) were made at each site. The length of each site was measured and the percentage of habitat composition visually estimated. Because shallow water habitats (≤ 1.5 ft) were inaccessible to the electrofishing boat, sampling was restricted to deep pool, shallow pool, and run/glide habitats. What dates?

Snorkel surveys were conducted by a team of three divers in each habitat type (deep pools, shallow pools, run/glide, and riffles) within each of the four reaches during May 1988. Because river reach one was comprised almost entirely of deep pool habitat, only deep pools were sampled. Three replicates of each habitat type present within each river reach were surveyed, resulting in a total of 39 sampling sites distributed throughout the study area. Snorkel surveys were conducted in all four IFIM sites, as well as in other areas of the river. In study sites where the linear

distance of the habitat was less than 300 ft, the entire length of the habitat was sampled. In areas where the linear distance of the habitat type exceeded 300 ft, observations were limited to a 300-linear-ft sample of the habitat.

Snorkel surveys were conducted using a team of three divers experienced in the underwater identification of fish. Observations were made by the divers, positioned in a straight line perpendicular to the shore, moving in the upstream direction. The lateral distance between divers was based on underwater visibility, adjusted at each site to ensure complete visual coverage of the area below the divers. In study sites where the river channel width exceeded the visual capability of the divers, multiple longitudinal passes were made. To minimize double counting of fish, the alignment and position of the divers in the river channel and the lateral distance between divers was maintained by verbal communication with a biologist stationed on the shoreline. The number, life stage, and identification (lowest taxonomic level possible) of fish observed was verbally communicated to the data recorder on shore.

Underwater visibility and water temperature were recorded at each site immediately prior to making observations. Water depth and velocity measurements were recorded at three equidistant points along each of three transects distributed equally along the length of the sampling sites and percent substrate composition was visually estimated at each site subsequent to the completion of snorkeling.

X was A total of 1,707 fish representing 13 species and seven families were collected by electrofishing (Table 6). Three species were collected in the Narrows Reach, ten species in both the Garcia Gravel Pit and Simpson Lane reaches, and six species in the Daguerre Point Dam Reach. Chinook salmon were found in all four reaches, while rainbow/steelhead trout were found in all of the reaches except the Narrows Reach. Species collected only in the Simpson Lane Reach included Pacific lamprey, smallmouth bass, and tule perch. Bluegill and speckled dace were collected only in the Garcia Gravel Pit Reach.

A total of 8,815 fish representing 13 species and eight families were observed by snorkeling during May 1988 (Table 7). Chinook salmon and rainbow/steelhead trout were observed in all four river reaches, and were the only fish species observed in the Narrows Reach. Sacramento squawfish, Sacramento sucker, smallmouth bass, and sculpin were represented in all three river reaches downstream of the Narrows Reach. Tule perch and hardhead were observed in the Daguerre Point Dam and Simpson Lane reaches, while speckled dace were observed in the Garcia Gravel Pit and Daguerre Point Dam reaches.

Table 6. List of fishes (all age classes) collected by electrofishing in the lower Yuba River, California, February and May 1987.

Common name	Species abbreviation	River reach*				Total
		1	2	3	4	
Pacific Lamprey	LP	-	-	-	13	13
Chinook salmon	CHIN	10	387	82	352	831
Rainbow trout	RT	-	7	-	4	11
Steelhead trout	SH	-	4	2	2	8
Speckled dace	SDC	-	10	-	-	10
Hardhead	HH	-	15	1	-	16
Sacramento squawfish	SQ	-	91	6	32	129
Sacramento sucker	SKR	2	386	23	128	539
Smallmouth bass	SMB	-	-	-	3	3
Green sunfish	GS	1	1	-	1	3
Bluegill	BG	-	1	-	-	1
Tule perch	TP	-	-	-	72	72
Riffle sculpin	RSC	-	18	3	50	71
Totals		13	920	117	657	1,707

* River Reach: 1 = Narrows Reach; 2 = Garcia Gravel Pit Reach; 3 = Daguerre Point Dam Reach; and 4 = Simpson Lane Reach.

Table 7. List of fishes (all age classes) collected by snorkeling in the lower Yuba River, California, in May 1988.

Common name	Species abbreviation	River reach*				Total
		1	2	3	4	
Pacific Lamprey	LP	0	6	16	89	111
Chinook salmon	CHIN	6	3,108	611	587	4,312
Rainbow trout(juv)	RT	3	1,649	143	34	1,829
Rainbow trout(adlt)	RT+	0	19	9	16	44
Unidentified salmonids	US	0	117	0	0	117
Speckled dace	DC	0	172	15	0	187
California roach	RCH	0	20	0	0	20
Hardhead	HH	0	0	7	5	12
Sacramento squawfish(juv)	SQ	0	89	236	436	761
Sacramento squawfish(adlt)	SQ+	0	23	55	11	89
Unidentified cyprinids	UC	0	2	0	77	79
Sacramento sucker(juv)	SKR	0	224	18	84	326
Sacramento sucker(adlt)	SKR+	0	403	228	29	660
Mosquitofish	MF	0	0	0	8	8
Smallmouth bass	SMB	0	1	2	1	4
Redear sunfish	RSF	0	0	5	0	5
Tule perch	TP	0	0	92	118	210
Riffle sculpin	RSC	0	12	24	5	41
Totals		9	5,845	1,461	1,500	8,815

* River Reach: 1 = The Narrows Reach; 2 = Garcia Gravel Pit Reach; 3 = Daguerre Point Dam Reach; and 4 = Simpson Lane Reach.

+ Indicates adult stage (see also Figure 7).

Shad sample
only may 1-10
too early down
were snorkeling
into the river

No American shad were seen in either snorkel or electrofishing samples possibly due to the low water conditions experienced during the spring of 1987 and 1988. Although not all species noted in earlier studies by Beak (1976) (Table 1) were observed during this investigation, two additional species were observed (tule perch and redear sunfish).

Species Relative Abundance and Macrohabitat Use

Relative abundance estimates calculated for all electrofishing sampling sites and periods combined, indicate that chinook salmon and Sacramento sucker were by far the most abundant species, comprising 49% and 32% of the total catch, respectively (Figure 6). These two species were followed in abundance by Sacramento squawfish (8%), tule perch (4%), and riffle sculpin (4%). All other species individually represented less than 1% of the total number of fish collected. Differences in relative abundance between results of electrofishing and snorkeling may be due to the difficulty of electrofishing the higher velocity areas with the electrofishing boat, such as that found in riffle habitat.

Relative abundance estimates calculated from snorkeling observations showed chinook salmon as the most abundant fish species, representing 49% of the total number of all fish observed (Figure 6).

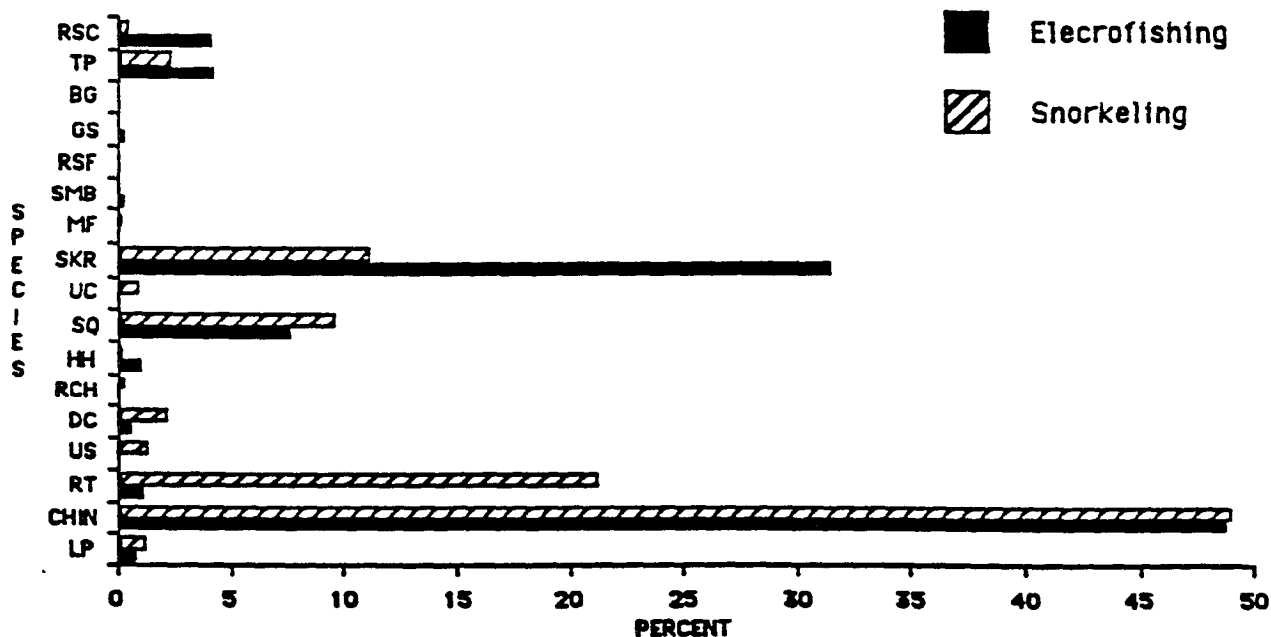


Figure 6. Overall relative abundance (percent of total number) of all fish species collected by electrofishing and observed by snorkeling in the lower Yuba River, California. Species abbreviations are presented in Tables 6 and 7.

Certain species exhibited trends in habitat type use. Chinook salmon densities were greatest in riffle and deep pool habitats (Figure 7). Nearly all of the salmon found in deep pool habitat were observed in the fast water component that entered at the head of the pool hydraulically similar to the conditions found in riffle and run/glide habitats. Rainbow/steelhead trout, speckled dace, and Pacific lamprey densities were highest in the fast water habitats (i.e., riffle and run/glide). This preference for high velocity habitat by rainbow/steelhead trout may explain why they were not found in abundance in results of electrofishing as compared to snorkeling since it was difficult to sample riffle habitat with the electrofishing boat. In contrast, adult Sacramento squawfish and Sacramento sucker were most abundant in deep pools, while the young of these two species displayed high densities in both deep and shallow pools.

Lengths and weights of juvenile chinook salmon captured by electrofishing were used to assess seasonal fish growth and calculate condition factors. Length-frequency distributions were generated for February and May collections. Average lengths of juvenile chinook salmon were calculated for each river segment for the February and May sampling (Table 8). Condition factors (K) were calculated according to Carlander (1969).

		River reach			
		Garcia	Daguerre		
		Gravel	Point		
		Pit	Dam		
	Narrows				Simpson Lane
Average fork length:					
February	1.87(8)	1.51(266)	1.57(82)		1.68(292)
May	2.40(2)	2.34(111)	--		2.69(60)
Condition factor:					
Feb + May	1.14(9)	1.14(300)	0.90(82)		1.16(347)

should not continue w/out testing

not sampled in Feb.

-28-

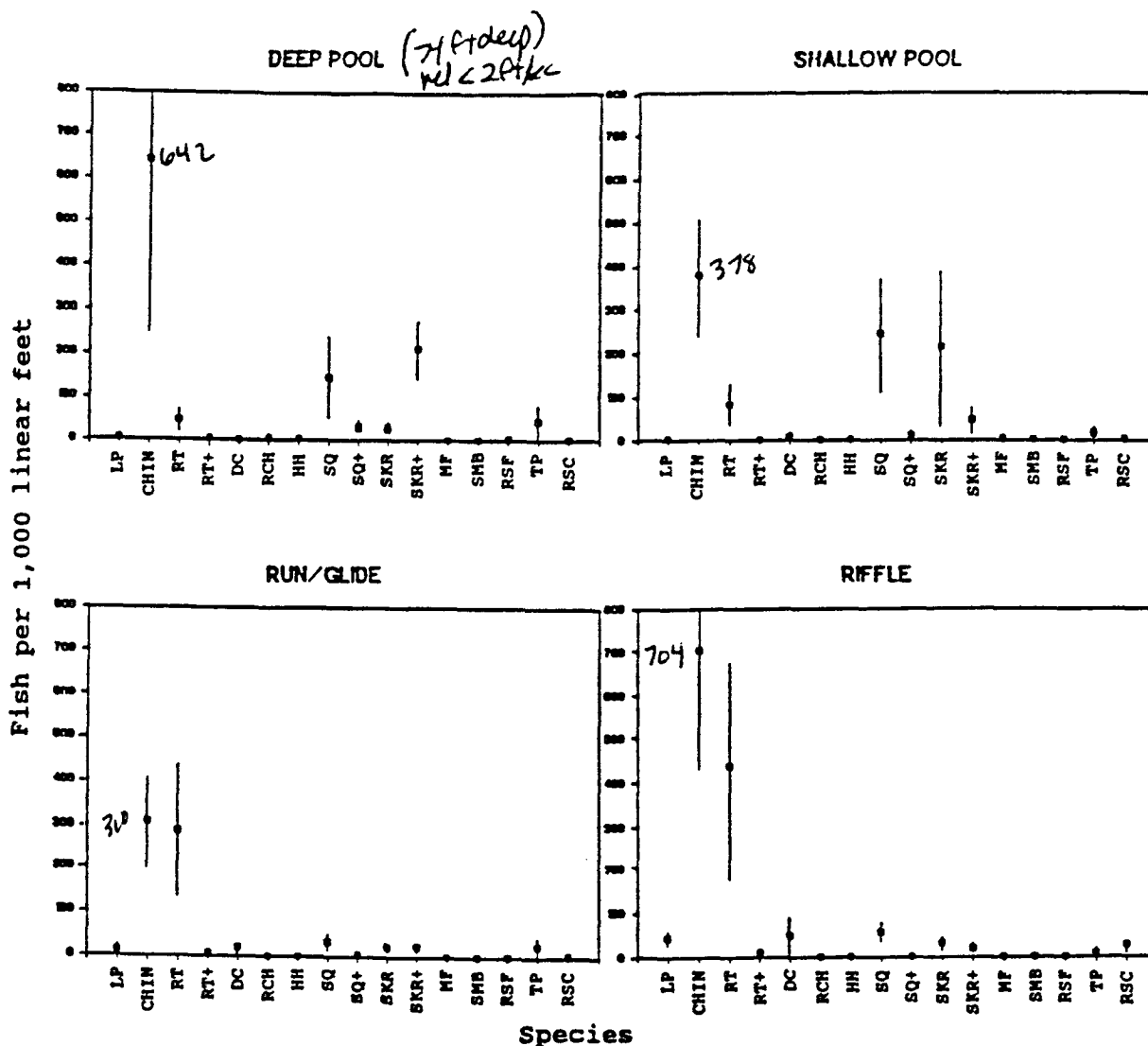


Figure 7. Average fish densities (fish per 1,000 linear ft) of all species observed by snorkeling in deep pool, shallow pool, run/glide, and riffle habitat types in the lower Yuba River, California, May 1988. Vertical bars equal \pm the standard error of the mean. Species abbreviations are presented in Tables 6 and 7.

remove
Determination of the existence of low condition factors
at this site was not possible

Average condition factor for 568 juvenile chinook salmon collected in February was 1.11, while that of 170 fish collected in May was 1.16. The average condition of fish during the February and May sampling in the Daguerre Point Dam Reach (0.90) was notably lower than that of fish in the other three reaches (1.14-1.16) (Table 8). This may be the result of stress emigrating salmon experience with passage by the dam or a reduced food supply in the area. Sampling at this site was conducted only in February since sampling was not possible in May due to the release by DFG of coded-wire tagged juvenile chinook into the sampling site area.

Conclusions

Electrofishing indicated that chinook salmon was the most abundant species found in all four study reaches. Snorkeling observations indicated rainbow/steelhead trout were found in all four reaches as well. No American shad were observed in any reach using either technique.

Young chinook salmon showed highest densities in riffle and the fast water component of deep pool habitats. Rainbow/steelhead trout abundance was highest in the fast water habitats, riffle and run/glide.

Calculations of chinook salmon condition factors showed an increase from 1.11 to 1.16 from February to the May sampling. Those fish sampled in the Daguerre Point Dam Reach had the lowest condition factor (0.90).

Electrofishing sampling by habitat

Most salmon in deep pools & riffles

	Deep Pool	Shallow Pool	Run/Glide	Riffle
Narrows	714 (100%)	0	0	0
Garcia Gravel Pit	0	1,156 (100%)	6,096 (64%)	0
Daguerre Pt Dam (below)	135 (20%)	0	526 (80%)	0
Simpson Lane	2,136 (53%)	197 (5%)	1,721 (42%)	0

comparable Habitat
- Sampled in Feb only

Beak Report Pg 27: "In May, chinook salmon densities showed a large decrease from the February estimates." Chinook salmon in Simpson Lane went from 140 fish/1000 ft to 29 fish/1000 ft.

Beak Report Pg 31. Average densities in Feb & May

	Garcia	Daguerre	Simpson
Feb	69 (n=3)	142 (n=2)	140 (n=3)
May	28 (n=3)		30 (n=3)

Small sample sizes

-30-

** All habitat use data for fry & juveniles collected in Daguerre Pt. Dam reach.

no measures of availability to account for any differences. Whole study baised.

Other habitat criteria (see pg 17 in Beck's habitat preference report).
not worth it - go with what we have

HABITAT CRITERIA

Habitat needs of fall- and spring-run chinook salmon, steelhead trout, and American shad in the lower Yuba River vary with the season of the year and the stage of their life cycle. Upstream spawning migration of adults, spawning, incubation, fry and juvenile rearing are the major life stages for these species. Water depth and velocity, substrate composition, and water temperature are habitat criteria used most often to describe habitat needs. Bovee (1986) defines habitat criteria as a set of characteristic behavioral traits of a species that establish standards for comparison.

A major goal of the lower Yuba River studies was to determine the relationship between usable fish habitat and discharge for these species through use of the Instream Flow Incremental Methodology (IFIM). Thus, an evaluation of microhabitat use was conducted to develop habitat criteria for use in the IFIM.

Another major study element was to evaluate water temperatures existing downstream of Englebright Dam. Therefore, temperature criteria were developed for spawning migration, spawning, incubation, and fry and juvenile rearing life stages from west coast literature to provide a reference point to which lower Yuba River temperature conditions can be compared.

Evaluation of Microhabitat Use

Studies were conducted in the lower Yuba River to develop microhabitat use criteria for mean column velocity, total mean depth, and substrate for various life stages of chinook salmon, steelhead trout, and American shad. Sufficient data were collected through direct observation of individual fish to describe each of three chinook salmon life stages: (1) fry < 2 in TL, (2) juveniles ≥ 2 in TL, and (3) spawning adults. Insufficient numbers of steelhead trout or American shad were observed during the 1987 field season to allow development of habitat criteria for these species.

The following parameters were measured for each observation: mean column velocity, total depth, and redd substrate composition. Water velocities were measured with a Marsh-McBirney current meter to the nearest 0.01 ft/s parallel to the current according to Trihey and Wegner (1981). Total depths were measured in metric and English units with USGS top-setting rods. Redd substrate composition was visually estimated and described using fifteen size categories (Table 9).

Total depth and mean column velocity criteria for each life stage were developed by applying the non-parametric tolerance limits method to the frequency of use distribution (Somerville 1958; Remington and Schork 1970; Bovee 1986). The non-parametric

Microhabitat Use (days sampled)

1. Flow 697-890 Fry Feb 12, 1987 -31-
396-416 Juv April 27-May 1, 1988
614-658 Spawners Nov 17-22, 1986

Some fry data collected in April & May were "limited in number & collected at different flows than occurred in February and were therefore not incorporated within the analyses." Beck Pg 24 habitat Report.

tolerance limits method involves calculation of cumulative frequencies in 0.1 ft or ft/s increments using both zero depth and zero velocity as individual intervals. Non-parametric tolerance limits were applied to each use frequency distribution and the use curves were developed following the methods prescribed by Bovee (1986).

Substrate criteria were further developed by combining the 15 defined substrate categories into the nine broader particle size classes of the commonly used Brusven Substrate Index (Brusven 1977) (Table 9). Criteria were developed using only the dominant substrate particle size because the sample size was too small to develop dominant-subdominant criteria. For each observation, the substrate category that contained the greatest percentage of material was defined as the dominant particle size (Aceituno et al. 1985). When substrate abundance was equal between substrate categories, dominance was assigned randomly. Observation frequency-of-use for each substrate category was summarized and normalized to develop habitat use functions.

Table 9. Classification system used for estimating substrate composition during fish habitat use observations in the lower Yuba River, California, 1986-1987.

Substrate code for recording observations	Brusven (1977) substrate code for data analysis	Substrate description	Size class (in)
1	1	organic debris	-
2	1	mud-soft clay	<0.002
3	1	silt	<0.002
4	1	sand	0.002- 0.10
5	1	coarse sand	0.10 - 0.25
6	2	small gravel	0.25 - 1.00
7	3	medium gravel	1.00 - 2.00
8	4	large gravel	2.00 - 3.00
9	5	small cobble	3.00 - 6.00
10	6	medium cobble	6.00 - 9.00
11	7	large cobble	9.00 -12.00
12	8	small boulder	12.00 -24.00
13	9	medium boulder	24.00 -79.00
14	9	large boulder	>79.00
15	9	bedrock	-

Fall-Run Spawning Chinook Salmon Criteria

Fall chinook salmon spawning habitat use data were collected November 17-22, 1986 at three locations: (1) below and near Highway 20 Bridge crossing, (2) below and within 1/4 mi of Daguerre Point Dam, and (3) near Plantz Road (Figure 2). Streamflow above and below Daguerre Point Dam varied from 820 to 858 cfs and 616 to 647 cfs, respectively, during sampling.

Occupied salmon redds were preferred for spawning habitat measurements, but vacant redds were also measured if recent completion was evident and hydraulic conditions had not changed significantly subsequent to completion. Each redd examined was individually flagged to prevent re-sampling.

At a redd location, measurements of mean column velocity, total depth and substrate were made to approximate habitat conditions prior to gravel disturbance caused during redd construction. All measurements were made 0.5 ft upstream of the leading edge along the mid-line of the redd. Sampling for spawning chinook salmon yielded 154 observations of habitat use for depth and velocity (Table 10).

Observations of total depth over redds ranged from 0.35 to 3.25 ft with the mean depth at 1.45 ft (± 0.54 S.D.) (Table 10). Fifty percent of the observations were in the depth interval 0.95-1.85 ft, which was assigned a use value of 1.00 (Table 11, Figure 8). A depth of 0.45 to 2.85 ft defined the 95% observation range, and was assigned a use value of 0.50. Compared to salmon spawning depth criteria for the Mokelumne River (Envirosphere 1988) and previously published criteria for other rivers (Bovee 1978; Vogel 1982; DFG 1990; Hampton 1988), depth ranges and maximum probabilities of Yuba and Mokelumne river distributions are very similar. In the Yuba and Mokelumne rivers, spawning chinook salmon utilized greater depths than reported by Bovee (1978) for several rivers and Vogel (1982) for Battle Creek, a tributary to the Sacramento River.

Observations of mean column velocity use over redds ranged from 0.0 to 4.55 ft/s with a mean of 2.26 ft/s (± 0.85 S.D.) (Table 10). Velocities within the range 1.55-2.95 ft/s accounted for 50% of the observations and was assigned a utilization value of 1.00 (Table 11, Figure 9). The upper and lower limits for the 95% observation interval were 4.45 and 0.35 ft/s, respectively.

Table 10. Habitat use observations for three life stages of fall-run chinook salmon in the lower Yuba River, California, 1986-1987.

Life stage	Sample size	Sample range	Mean \pm SD	Median	Sample coefficient of variation (%)
Mean column velocity (ft/s):					
Fry	180	0.00-2.15	0.34 \pm 0.45	0.11	134
Juvenile	499	0.00-3.15	0.96 \pm 0.64	0.75	76
Spawning	154	0.00-4.55	2.26 \pm 0.85	2.27	38
Total depth (ft):					
Fry	180	0.35-3.15	1.22 \pm 0.61	1.15	50
Juvenile	500	0.15-2.95	1.06 \pm 0.57	0.95	54
Spawning	154	0.35-3.25	1.45 \pm 0.54	1.47	37

* Deep pools not sampled. Not represented in sample but yet 2nd highest salmon densities. Study biased here. Velocities lowest in pools.

Juvenile data collected April 27-May 2, after Feb 1 May sampling showed where fish were.

Table 11. Total depth and mean column velocity habitat use criteria for fry, juvenile, and spawning fall-run chinook salmon in the lower Yuba River, California, 1986-1987. Criteria developed by the non-parametric tolerance limit method.

Total depth			Mean column velocity		
Midpoint of depth interval (ft)	Tolerance limit of P at the 90% CL*	Use probability index+	Midpoint of velocity interval (ft/s)	Tolerance limit of P at the 90% CL*	Use probability index+
Fry:					
0.00	0.00	0.00	0.00	0.90	0.20
0.25	0.00	0.00	0.05	0.50	1.00
0.35	0.95	0.10	0.45	0.50	1.00
0.45	0.75	0.50	1.05	0.75	0.50
0.75	0.50	1.00	1.25	0.90	0.20
1.45	0.50	1.00	1.85	0.95	0.10
2.15	0.75	0.50	2.25	0.00	0.00
2.25	0.90	0.20			
2.85	0.95	0.10			
3.25	0.00	0.00			
Juvenile:					
0.00	0.00	0.00	0.00	0.95	0.10
0.15	0.95	0.10	0.05	0.90	0.20
0.25	0.90	0.20	0.35	0.75	0.50
0.45	0.75	0.50	0.55	0.50	1.00
0.55	0.50	1.00	1.25	0.50	1.00
1.45	0.50	1.00	1.75	0.75	0.50
1.75	0.75	0.50	2.25	0.90	0.20
2.25	0.90	0.20	2.95	0.95	0.10
2.45	0.95	0.10	3.15	0.99	0.02
2.95	0.99	0.02	3.25	0.00	0.00
3.05	0.00	0.00			
Spawning:					
0.00	0.00	0.00	0.00	0.95	0.10
0.25	0.00	0.00	0.35	0.95	0.10
0.45	0.95	0.10	0.85	0.90	0.20
0.65	0.90	0.20	1.25	0.75	0.50
0.75	0.75	0.50	1.55	0.50	1.00
0.95	0.50	1.00	2.95	0.50	1.00
1.85	0.50	1.00	3.25	0.75	0.50
2.15	0.75	0.50	3.85	0.90	0.20
2.55	0.90	0.20	4.45	0.95	0.10
2.85	0.95	0.10	4.65	0.00	0.00
3.35	0.00	0.00			

* P equals the proportion of the population between the rth smallest and the sth largest value in a random sample of N from a population having a continuous but unknown distribution function (Somerville 1958).

+ Use probability equals $2(1-P)$.

Greatest habitat use for the Mokelumne River was for the velocity 2.70 ft/s (Envirosphere 1988). The frequency of use distributions for the two rivers were similar to those reported by Kurko (1977) for the Skagit River, Washington, Vincent-Lang et al. (1984) for tributaries of the Middle Susitna River, Alaska, DFG (1990) for the Sacramento River, California, and Hampton (1988) for the Trinity River, California. However, spawning fish in the Yuba and Mokelumne rivers use faster velocity water than reported by Bovee (1978).

Sampling of spawning chinook salmon substrate use was restricted to 146 observations. Conditions upstream of eight redd sites were disturbed, preventing substrate evaluation (Table 12). Dominant substrate use for redd construction in the lower Yuba River by spawning chinook salmon was greatest for small cobble (3 to 6 in in diameter). This is substrate code 5 and received a utilization value of 1.00 (Table 12, Figure 10). The next greatest dominant particle size was large gravel (2 to 3 in in diameter) with a substrate code of 4 and assigned a utilization value of 0.56. EnviroSphere (1988) reported Mokelumne River substrate utilization was the same as for the lower Yuba River for substrate codes 5, 6, and 7 while no utilization was noted for substrate codes 1 through 4. DFG (1990) and Hampton (1988) reported substrate code 4 as the dominate particle size for the Sacramento and Trinity rivers, respectively.

Fall-Run Fry Chinook Salmon Criteria

Sampling for fry and juvenile chinook salmon life stages was conducted by an underwater observer. Measurements of habitat use were based upon direct observation of fish. Each individual fish observed was counted as one sample. The observer marked each site for mean column velocity, total depth, and substrate measurements.

Criteria development for the chinook salmon fry life stage was based upon sampling during the first two days of February 1987 at the Hallwood Avenue site (Figure 2). Mean daily flows at the USGS gage near Marysville were 697 and 890 cfs, respectively (USGS 1987).

Fry use observations for total depth and mean column velocity were based upon 180 fish. Fry were observed in depths ranging from 0.35 to 3.15 ft (Table 10). Fifty percent of all use observations were within 0.75 to 1.45 ft, and a use criteria of 1.00 was assigned to this range (Table 11, Figure 11). The 95% range of observations was from 0.35 to 2.85 ft. An index of 0.10 was assigned to this range. Depth utilization in the Mokelumne River (Envirosphere 1988) was highest at 1.70 ft, compared to 0.75 to 1.45 ft in the Yuba River, while DFG (1990) and Hampton (1988) reported maximum preference between 0.75 and 1.5 ft for other California rivers.

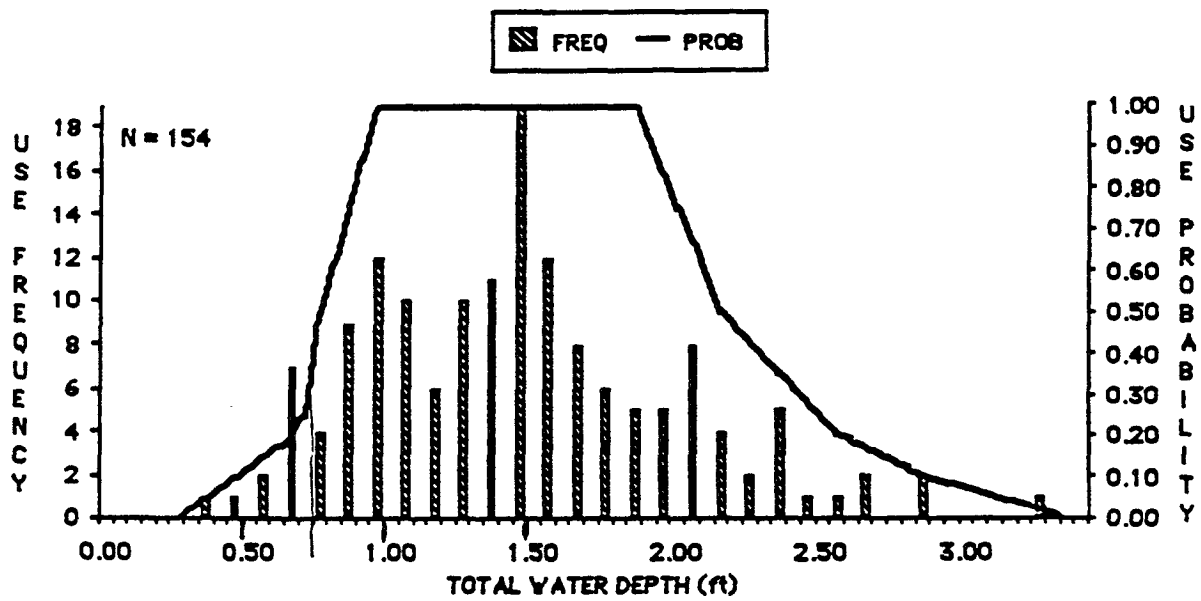


Figure 8. Chinook salmon spawning total depth use frequency and probability in the lower Yuba River, California.

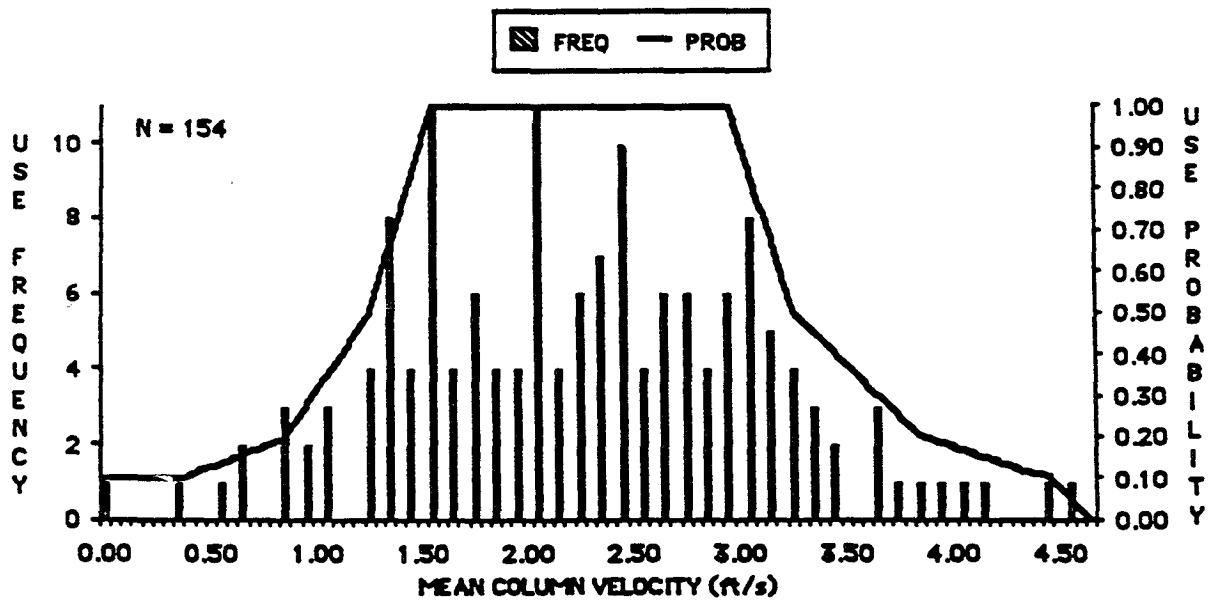


Figure 9. Chinook salmon spawning mean column velocity use frequency and probability in the lower Yuba River, California.

Mean column velocity used by fry ranged from 0.0 to 2.15 ft/s (Table 10). Fifty percent of the habitat use observations were within the 0.05 to 0.45 ft/s range resulting in a maximum criteria value of 1.00 (Table 11, Figure 12), which is similar to use in the Mokelumne River (Envirosphere 1988), and as reported in other rivers by Burger et al. (1982), DFG (1990), and Hampton (1988). The limits for the 95% interval were 0.0 to 1.85 ft/s.

Table 12. Dominant substrate utilization criteria for spawning chinook salmon in the lower Yuba River, California, 1986-1987.

Brusven (1977)

substrate code

normalized for data analysis	Substrate description	Size class (in)	Frequency of use	Use index
1	coarse sand & fines	<0.25	8	0.14
2	small gravel	0.25 - 1.00	8	0.14
3	medium gravel	1.00 - 2.00	25	0.45
4	large gravel	2.00 - 3.00	32	0.57
5	small cobble	3.00 - 6.00	56	1.00
6	medium cobble	6.00 - 9.00	16	0.29
7	large cobble	9.00 - 12.00	1	0.02
8	small boulder	12.00 - 24.00	0	0.00
9	medium boulder to bedrock	≥24.00	0	0.00
			Total	146

Fall-Run Juvenile Chinook Salmon Criteria

Criteria development for the juvenile life stage was based upon sampling conducted from April 27 through May 1, 1988 at the Plantz Road site and Hallwood Avenue site downstream of Daguerre Point Dam (Figure 2). Streamflow at the Marysville gage ranged from 346 to 416 cfs during the survey.

The range of total depth used by juvenile chinook salmon was 0.15 to 2.95 ft with a mean depth of 1.06 ft (\pm 0.57 S.D.) (Table 10). The 50% observation range for the use distribution was 0.55 to 1.45 ft with use index calculated at 1.00 (Table 11, Figure 13). Depth of highest utilization reported by Suchanek et al. (1984) for tributaries of the Susitna River, Alaska, was between 1.0 and 1.55 ft. Bovee (1978) reported maximum use of depth \geq 1.5 ft in several Idaho river systems, while for California rivers, maximum preference was for depths $>$ 1.0 ft in the Trinity River (Hampton 1988) and $>$ 3.0 ft in the Sacramento River (DFG 1990).

Mean column velocity used by juveniles ranged from 0.0 to 3.15 ft/s (Table 10). The maximum use index value of 1.00 encompassed the range 0.55 to 1.25 ft/s (Table 11, Figure 14). Velocities of 0.0 and 2.95 ft/s defined the limits of the 95% observation range, receiving a utilization value of 0.10. Juveniles in the lower

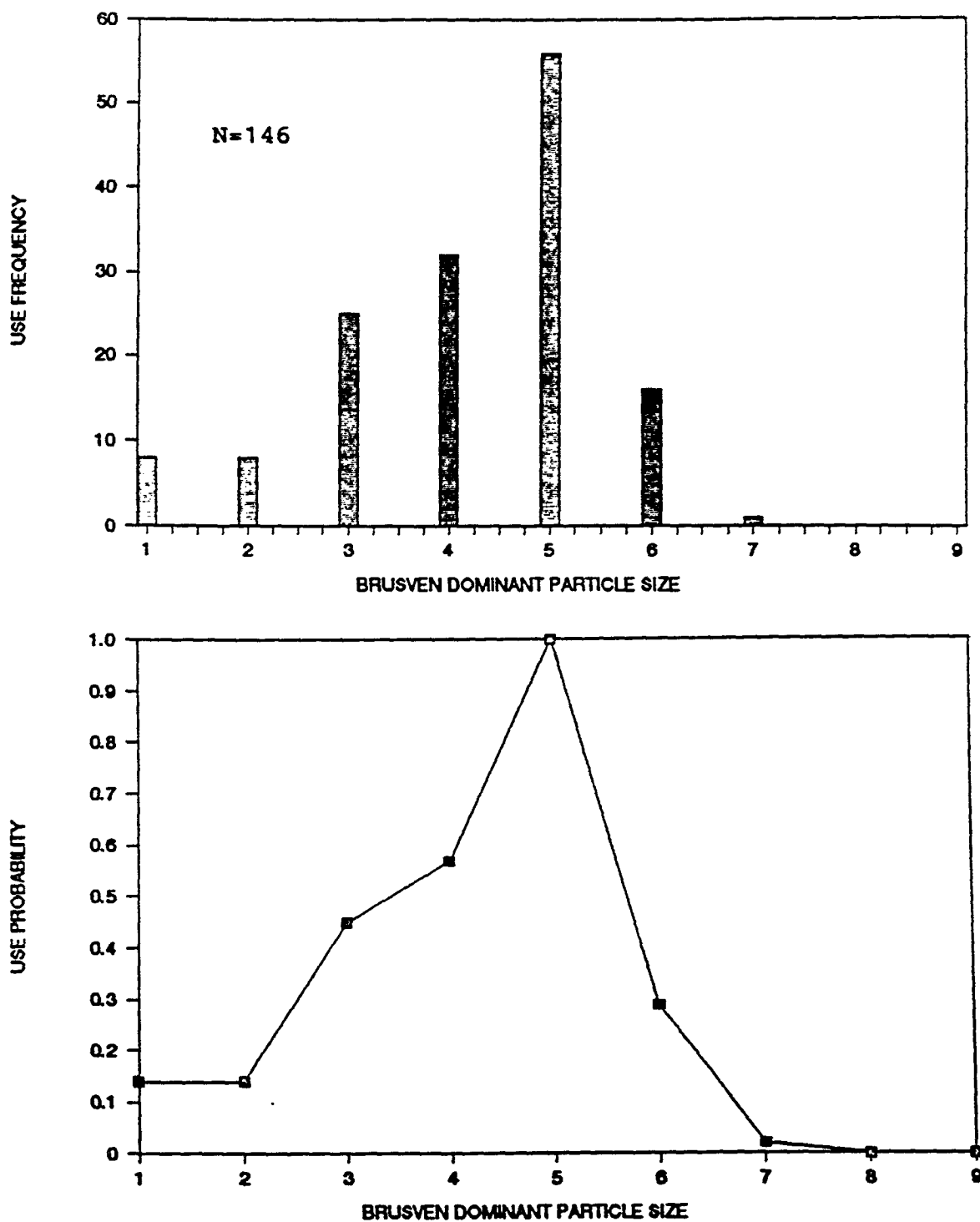


Figure 10. Chinook salmon spawning substrate use frequency and use probability in the lower Yuba River, California.

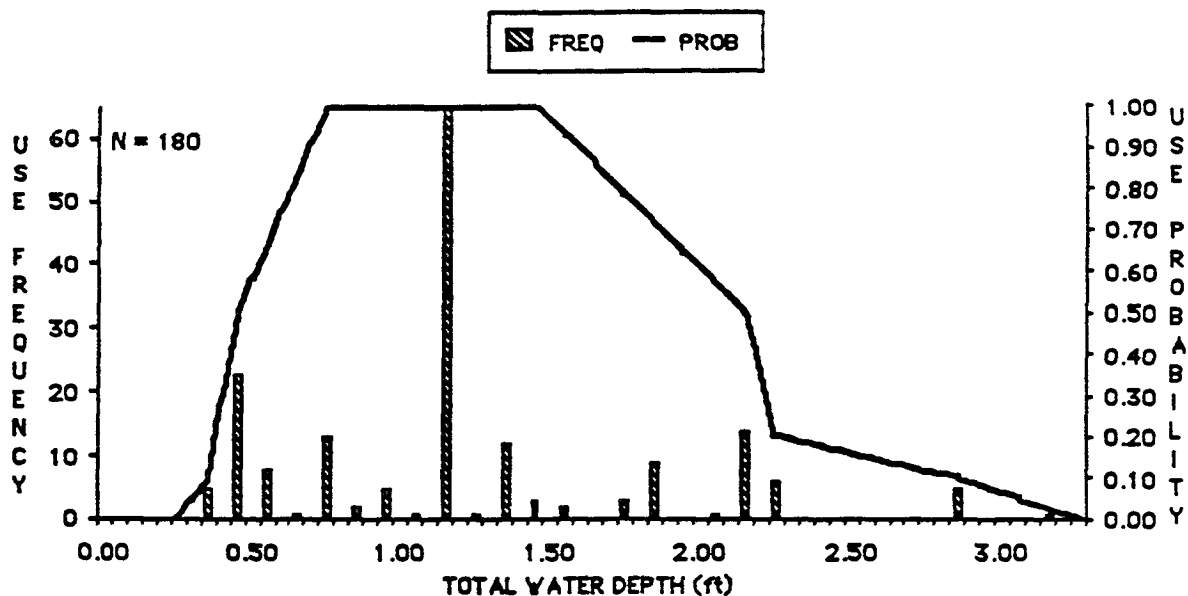


Figure 11. Chinook salmon fry total depth use frequency and use probability in the lower Yuba River, California.

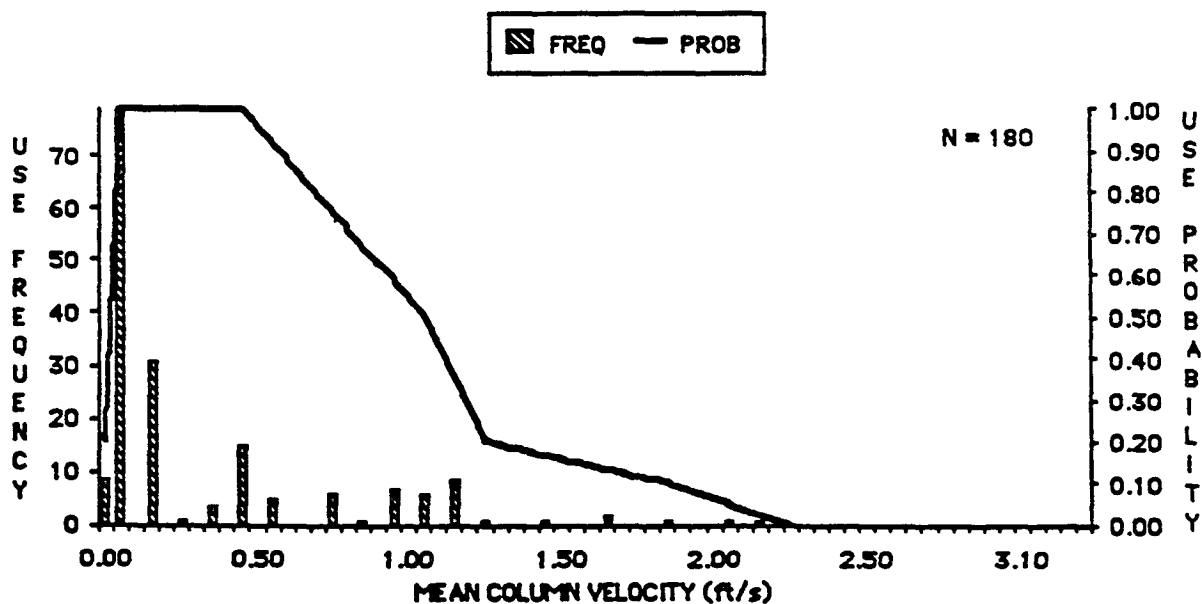


Figure 12. Chinook salmon fry mean column velocity use frequency and use probability in the lower Yuba River, California.

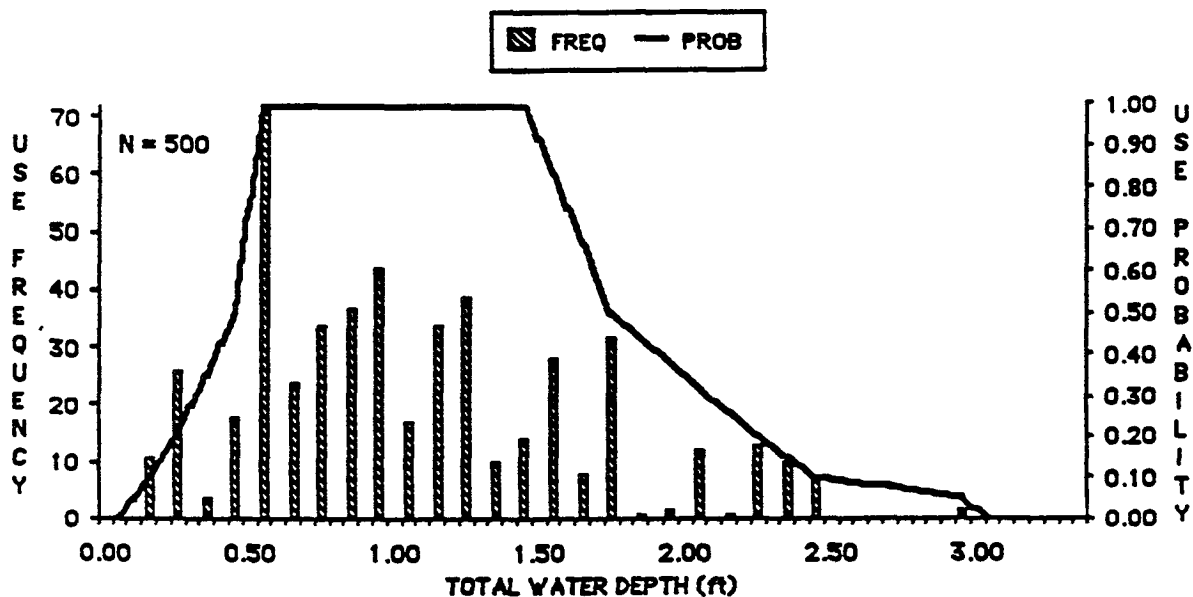


Figure 13. Chinook salmon juvenile total depth use frequency and use probability in the lower Yuba River, California.

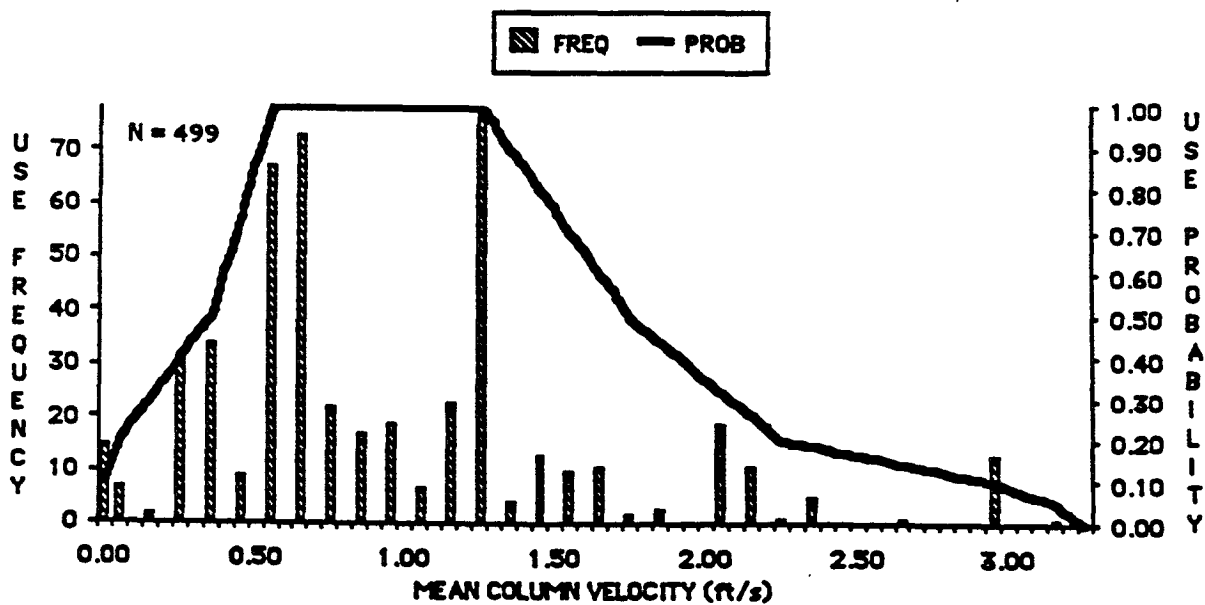


Figure 14. Chinook salmon juvenile mean column velocity use frequency and use probability in the lower Yuba River, California.

Yuba River utilized somewhat higher velocities than reported by Suchanek et al. (1984) and Bovee (1978) where maximum utilization was 0.30-0.70 ft/s and 0.60 ft/s, respectively. Maximum preference reported by DFG (1990) and Hampton (1988) was 0.5 ft/s and 0.0 ft/s, respectively. JME

Steelhead Trout Criteria

I doubt it.
Evaluation of microhabitat for steelhead trout was not possible since extensive examination of the lower Yuba River failed to locate sufficient numbers to allow habitat use data to be prepared. In the absence of data collected specifically for the lower Yuba River, it is the DFG's policy to use habitat criteria presented by Bovee (1978) for the fry, juvenile, and spawning life stages.

Water Temperature — *This needs a thorough review.*

Water temperature is a primary factor affecting growth and survival of fishes in the lower Yuba River. Because of limited temperature tolerance, chinook salmon, steelhead trout, and American shad are more susceptible to temperature related problems of stress than are other species of the lower Yuba River (e.g., Sacramento sucker, hardhead, and Sacramento squawfish). There is a preferred water temperature range at which growth and survival are optimum for each of these species of concern. Generally as temperatures increase above these preferred ranges, mortality rates increase, growth is reduced, and susceptibility of the fish to disease increases. Temperatures below these preferred ranges result in reduced growth.

criteria - not all are preferred
Table 13 summarizes the published literature of Pacific Coast water temperature preferences for fall- and spring-run chinook salmon, steelhead trout, and American shad. Where possible, preferred water temperatures were selected from river systems similar to the Yuba River, such as the Feather River and American River. The temperature ranges were selected where they could be associated with a life stage that was identified by the respective author. The life stages are: spawning migration, spawning, egg incubation and emergence, fry rearing, and juvenile rearing.

Fall-Run Chinook Salmon

The preferred range for fall-run chinook salmon upstream migration is 44.1-57.5°F, spawning is 41.0-57.0°F, egg incubation through fry emergence is 41.0-57.9°F, fry rearing is 44.6-57.2°F, and juvenile rearing is 45.1-58.3°F (Table 13).

Spring-Run Chinook Salmon

The preferred temperature range of 37.9-55.9°F for spring-run chinook salmon migration is lower than for fall-run at 44.1-57.5°F (Table 13). The spring-run period of summer holding in deep

pools, commonly found in upstream canyon areas, necessitates tolerance of warmer water temperatures that should seldom exceed 69.8-77.0°F (Moyle 1976). Studies by USFWS staff on the Trinity River suggest spring-run chinook salmon select water temperatures less than 60°F (R. Brown, USFWS, Lewiston, CA, per. comm. 1990). However, Bell (1986) cites 77.0°F as the upper incipient lethal level for chinook salmon. Boles et al. (1988) states the maximum temperature for maintenance of adult chinook salmon in the river while eggs are maturing should be less than 60.0°F. Preferred spawning temperatures are 40.0-57.0°F and the preferred water temperature range for egg incubation is 41.0 to 57.9°F, the same as for fall-run. No reference for fry and juvenile rearing temperature requirements were found, but are assumed to be the same as for fall-run.

Table 13. Preferred water temperature (°F) ranges for various life stages of fall- and spring-run chinook salmon, steelhead trout, and American shad.

Chinook salmon		Steelhead	American
Fall-Run	Spring-Run	Trout	Shad
Spawning migration:			
49.0-57.5 a/	37.9-55.9 a/	46.0-52.0 b/	57.2-66.2 f/
44.1-55.9 b/			48.9-54.0 a/ - too low
			61.0-64.9 b/
Spawning:			
42.1-57.0 c/	42.1-57.0 c/	39.0-48.9 a,c/	60.1-70.0 g/
44.1-55.9 b/	40.0-55.0 d/	46.0-52.0 b/	59.9-70.0 a/
41.0-56.0 d/			61.0-64.9 b/ - too low
Egg incubation and emergence:			
41.0-57.9 c/	41.0-57.9 c/	50.0 a/	60.8-65.3 f/
46.0-54.0 b/		48.0-52.0 b/	57.9-66.0 a/ - too low
			61.0-64.9 b/
Fry rearing:			
44.6-57.2 e/		55.0-60.1 b/	59.9-69.8 f/
53.1-55.9 b/			
Juvenile rearing:			
45.1-58.3 c/		45.1-58.3 c/	59.9-69.8 f/
53.1-55.9 b/		55.0-60.1 b/	

a/ Bell (1986)

b/ Rich (1987)

c/ Reiser and Bjornn (1979)

d/ Chambers (1956)

e/ Raleigh et al. (1986)

f/ Painter et al. (1979)

g/ Painter et al. (1977)

Where is Boles et al. 1988 (cited pg 42)?
Where is Strick & Crutcher 2 for shad?

Steelhead Trout

The preferred temperature range for steelhead spawning migration is 46.0-52.0°F, while the preferred temperature range for spawning is 39.0-52.0°F, and the preferred range for incubation and emergence is 48.0-52.0°F (Table 13). Fry and juvenile rearing requirements follow with a preferred temperature range of 55.0-60.1°F and 45.1-60.1°F, respectively.

American Shad

preferred spawning higher than preferred incubation?

The preferred temperature range for American shad spawning migration is about 48.9-66.2°F (Table 13). Spawning and egg incubation preferred temperatures are about 59.9-70.0°F and 57.9-66.0°F, respectively. Preferred fry and juvenile rearing requirements are 59.9-69.8°F.

Discussion

American shad habitat criteria have not been developed for use in the IFIM from observations of shad using the lower Yuba River. DFG has no set of criteria in the absence of on-site criteria since Bovee (1978) does not contain criteria for American shad. The criteria used in this investigation are based on available information and DFG unpublished data. Additional on site studies are needed to develop on site criteria to refine the habitat/discharge relationships for this species. American shad habitat requirements may be so unique and critical that for successful upstream migration, spawning, incubation, and fry and juvenile rearing, criteria in addition to depth, velocity and substrate may need to be developed.

Only temperature.

Conclusions

Lower Yuba River habitat use criteria for total depth and mean column velocity for the three life stages of chinook salmon investigated are reasonably similar to criteria reported in the literature. Substrate criteria for the spawning life stage are also similar to other reported values. These criteria are of sufficient quality to use in evaluating the effects of incremental changes in discharge on the quantity of physical habitat available to fall-run chinook salmon. Insufficient spring-run fish were observed to develop criteria for that race and habitat criteria were not available from the literature for all life stages. Thus, information collected for Yuba River fall-run chinook is believed to be the most useful in describing the needs of Yuba River spring-run chinook salmon and was used in the analysis of spring-run needs.

In the absence of habitat use data for Yuba River steelhead trout, use criteria for depth, velocity, and substrate taken from Bovee (1978) were used for the life stages of fry, juvenile, and spawning.

The preferred temperature criteria developed in Table 13 are assumed to be applicable to the anadromous species of the lower Yuba River. Where more than one author is cited for a life stage and species, there is close agreement of preferred temperature requirements for all species considered. In addition, preferred temperatures for fall- and spring-run chinook salmon and steelhead are very similar. No information was available for the spring-run life stages of fry and juvenile rearing and are assumed to be similar to those for fall-run chinook salmon.

Does this validate criteria? No!

calibration is necessary. I don't
trust this model? Needs digging here.

WATER TEMPERATURE

Water temperature in the lower Yuba River is affected by the operations of Englebright and New Bullards Bar reservoirs. Existing water temperatures were examined to determine existing water temperature regimes. Water temperature/flow relationships were modeled using the Stream Network Temperature Model (SNTMP) (Theurer et al. 1984). Results of these studies are used to identify temperature conditions of the lower Yuba River, and to evaluate conditions that could adversely affect aquatic life.

Late-spring, summer, and early-fall water temperatures in the lower Yuba River primarily are a function of the release water temperature and magnitude of flows released from Englebright and New Bullards Bar reservoirs. The capacity of Englebright (70,000 AF) is relatively small, and the pool of cooler water available for use in controlling late spring, summer, and early fall temperatures is limited. Completion of New Bullards Bar Reservoir in 1969 greatly enhanced storage (961,300 AF) on the river, and the opportunity to use the increased volume of cool water to reduce water temperatures in the lower Yuba River. The dam is equipped with a adjustable subsurface intake to enable the YCWA to control downstream water temperatures.

So, don't
in low 50°F
range of
mid-October
before.

Application by YCWA for Davis-Grunsky Grant funding anticipated providing temperatures between 46°F and 56°F during the period October 1 through March 31 with reasonable efforts to maintain a constant temperature of 52°F in the spawning area (DWR 1966). By mutual agreement between DFG and YCWA, temperature has been controlled since completion of the project by operating the facility twice each year: changing to the high level outlet in April and then to the low level outlet in September (Donn Wilson, YCWA, per. comm. 1991). This twice yearly operation has reduced temperatures during the October through March period, but the temperature goals have not been fully achieved, particularly during October and early November (Figure 15).

The results of these temperature studies are interpreted with respect to published literature on water temperature preferences for fall- and spring-run chinook salmon, steelhead trout, and American shad. Table 13 summarizes the published information of Pacific Coast water temperature preferences for these species and provides a reference point to which lower Yuba River temperature conditions may be compared.

Existing Water Temperature

The effects of increased storage capacity and dam operations on water temperature are evident from comparison of lower Yuba River temperatures near Marysville prior to and after construction of New Bullards Bar Dam. Daily maximum and minimum temperatures near

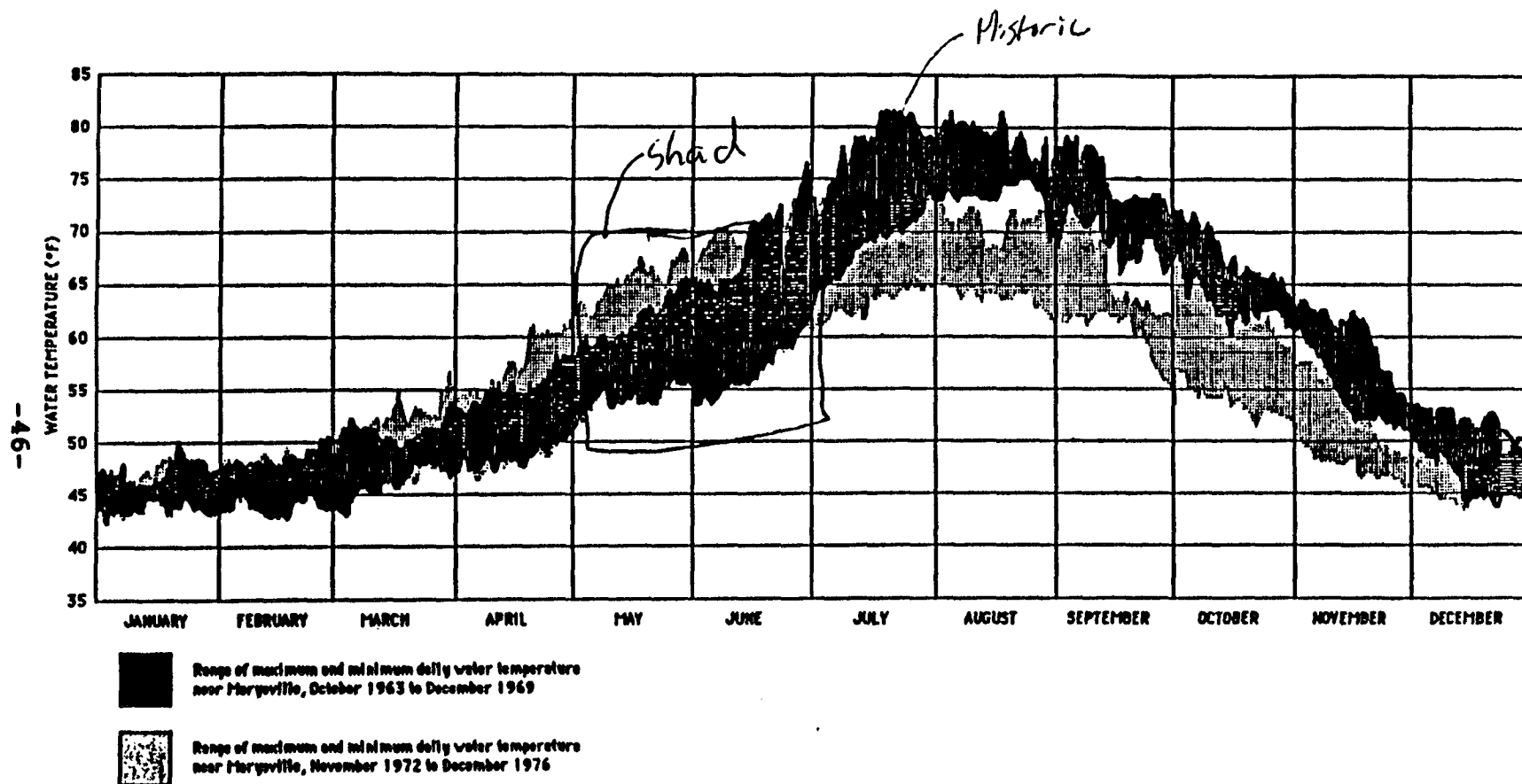


Figure 15. Comparison of range of lower Yuba River maximum and minimum daily water temperatures near Marysville, California, before (1963-69) and after (1972-76) construction and operation of New Bullards Bar Dam (modified from USACE 1977).

Are these 2 sets of
years hydrologically
similar? NO

True? Marysville for the period 1963-1969 (prior to operation of the dam) and for the period 1972-1976 (during operation of the dam) are shown in Figure 15. The data are incomplete for mid-September to early October 1974 maximum temperatures, and for early October 1975 minimum temperatures. Increased storage capacity has little influence on river temperature from mid-December through early March. However, from early March through mid-June, water temperatures tend to be increasingly warmer as spring progresses than they were before New Bullards Bar Dam was constructed. From early July through mid-December, temperatures are generally cooler due to operation of the enlarged dam.

Patterns of existing water temperatures in the lower Yuba River are due to a variety of factors in addition to the temperature of water released from New Bullards Bar and Englebright dams. These include: solar heating or cooling in transit to the confluence with the Feather River, transit time, and diversion rates.

Potential Effects of Existing Water Temperature on Anadromous Fishes

Water temperature records at USGS gages below Englebright Dam and near Marysville were used to assess the potential effects of post-new Bullards bar dam water temperatures in the lower Yuba River on fall- and spring-run chinook salmon, steelhead trout and American shad. The most consistent recent period of record for these gages is for the 1973 through 1978 water years where the data were reduced to mean weekly water temperatures to illustrate general trends. No temperature records are available following the 1978 water year.

Mean weekly maximum and minimum water temperatures for each water year are shown in Figure 16. The mean weekly minimum temperature below Englebright Dam and the mean weekly maximum temperature near Marysville approximate the range of temperatures in the lower Yuba River. The annual range of mean weekly temperatures varied from 40.1-81.5°F. The 1973, 1976 and 1977 water years were characterized by higher annual temperature range (40.1-81.5°F) than were 1973, 1975, and 1978 (41.9-72.5°F). Lower Yuba River discharges for the 1973 to 1978 water years are contained in Appendix I.

Fall-Run Chinook Salmon

Warm water temperatures near the confluence of the lower Yuba and Feather rivers during late September and October could delay upstream migration into the Yuba. The likelihood of a delay increases as temperatures rise above about 57.5°F (Table 13). In all years evaluated, water temperatures in the lower river were near the upper range or exceeded the preferred range during September (Figure 16). The preferred range was also exceeded during early October of water years 1975 and 1978. Hence, upstream migration could be delayed by as much as 1.5 months in

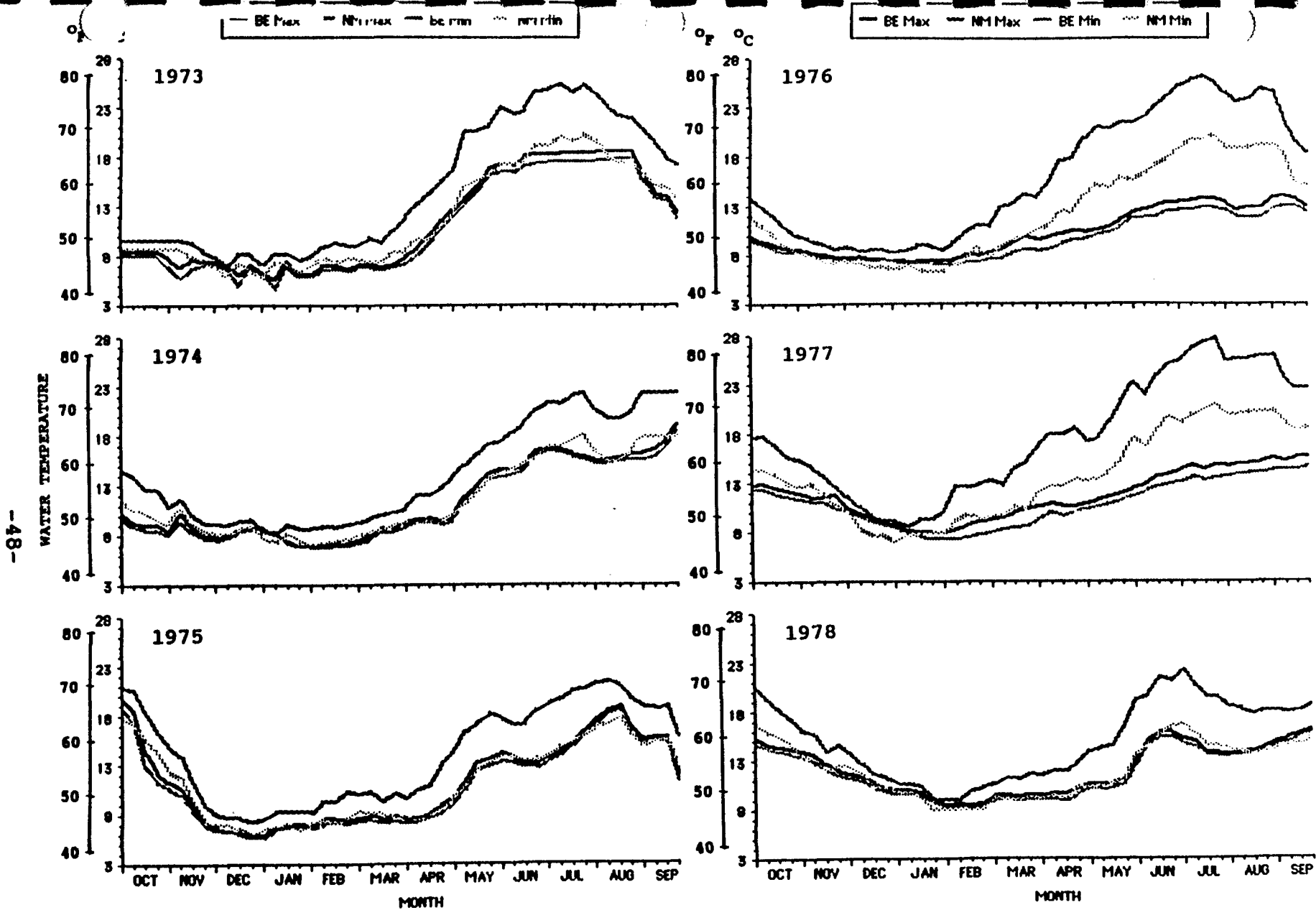


Figure 16. Mean maximum (Max) and minimum (Min) weekly water temperatures below Englebright Dam (BE) and near Marysville (NM), California, for water years 1973 through 1978.

*Pg 47-51 discuss this
table w/ life histories.*

REAL DATA?

these years. Conditions for migration after mid-October were satisfactory during all years.

The preferred temperature range for spawning (41.0-57.0°F) was exceeded at Marysville until mid-October in water year 1974, and early to mid-November during water years 1975, 1977, and 1978 (Table 13, Figure 16).

mid October

The preferred water temperature range for egg incubation through fry emergence is 41.0-57.9°F (Table 13). However, Boles et al. (1988) cites the range 53.0-57.5°F as providing the highest survival in eggs from Sacramento River chinook salmon (race not specified). Lower temperatures would reduce the rate of development and delay hatching, while higher temperatures would increase metabolism resulting in enhanced demand for dissolved oxygen and removal of carbon dioxide in the redds. Higher temperatures would also increase susceptibility to disease, and the incidence of abnormal growth (Boles et al. 1988). During the incubation period (October through February), water temperatures generally exceeded the optimum only during the first half of October (Figure 16). However, in water years 1975, 1977, and 1978 above preferred temperatures occurred as late as early-November.

The temperature range for fry rearing indicates that portions of the river were below optimum during late winter and early spring of water years 1973, 1975 and 1976 (Table 13, Figure 16). By early April, water temperatures typically exceed preferred temperatures for juvenile rearing in the lower river. By June, even the water released from Englebright Reservoir exceeded the preferred range during 1973, 1974, and 1978. Hence, by June there was not any portion of the river with preferred temperatures during these years. These temperatures may cause fry and juveniles to leave the river soon after emergence. However, early departure from natal rivers apparently is the rule for California chinook, with most fry spending only 3 to 4 weeks in fresh water (Moyle 1976). Chinook salmon juveniles in the Trinity River also spend a limited period rearing before migration downstream, with most leaving the upper river by June (R. Brown, USFWS, Lewiston, CA, per. comm. 1990). This is in spite of temperatures that are generally within the preferred range. The vast majority of juvenile chinook emigrate to the Sacramento-San Joaquin estuary where their peak movement typically occurs in April, May, and June (Moyle 1976; Kielson and Brandes 1988). Small numbers of juveniles spend up to one year in the river or estuaries (Moyle 1976).

Benefitted from N88 Rrs. because of cold temps.

Spring-Run Chinook Salmon

During spring, cool temperatures attending high flows in the lower Yuba River in normal to wet years seem unlikely to be stressful to upstream migrating spring-run salmon (Figure 16). However, in dry years (1976 and 1977 water years), water temperatures near Marysville may be detrimental. More importantly, dry years, low

flows, and high temperatures may block access to the deep pool holding habitat in the Narrows Reach. Water temperatures in the area just below the Narrows Powerhouse may be assumed to be nearly the same as those measured at the USGS gage below Englebright Dam. If so, water temperatures in this area were below the preferred level cited by Moyle (1976) and Bell (1986) of 69.8-77.0°F during the summer of 1973 to 1978 water years, but exceeded the 60.0°F cited by Boles et al. (1988) during the summer and early fall of 1973, 1974 and 1975.

Chambers (1956) reported that spring-run chinook salmon spawn in 40.0 to 55.0°F. This temperature range is a slightly lower temperature range than for fall-run (Table 13). In addition, spring-run salmon normally spawn a few weeks earlier than fall-run. However, these life history features characterize spring-run stocks that had access to their ancestral spawning areas at higher elevations. In these higher elevation habitats, water temperatures cool earlier than in the lower elevation habitat used by fall-run stocks. In the lower Yuba River, Englebright Dam and other dams located further upstream have blocked access to natural spawning habitat, so that the historical patterns may not characterize current habitat use in the river.

It is assumed that the 40.0 to 55.0°F temperature range for spring-run spawning would be preferred by the Yuba River stock during fall (late September through early November) in the upper portion of the river. Figure 16 shows that for water years 1973-1978 water temperatures in the lower Yuba River regularly exceeded 55.0°F during most of September, including the area just below Englebright Dam where spring-run have been observed to spawn. In October of water years 1973, 1974, 1976, and 1977, temperatures in the upper portion of the river were probably suitable for spawning. In the remaining years, water temperatures in the upper portion of the river exceeded the preferred range until late October to early November.

The preferred water temperature range for spring-run salmon egg incubation is the same as for fall-run (Table 13). Since the incubation period is slightly earlier, water temperatures below Englebright generally exceeded the preferred range during September and October for the water years 1974, 1977, and 1978.

Steelhead Trout

The warm water temperatures in the lower part of the river generally exceeded the steelhead trout spawning migration preferred range in September and October (Table 13, Figure 16). In some years, the preferred range was exceeded even into November and early December. Warm water created stressful conditions for fish that did migrate, or delayed upstream migration until the water cooled. Upstream migration may not have occurred until early to mid-November in water years 1974, 1975, and 1976 and as late as early December to mid-January in 1977 and 1978.

From the 1973 through 1978 water years, water temperatures below Englebright Dam during most of the spawning period (January through April) were near optimum (Table 13, Figure 16). However, in most years the mean weekly maximum temperature near Marysville exceeded the preferred range during much of the spawning period. The 1977 water year is the most extreme example in which the mean weekly maximum temperature near Marysville exceeded the preferred range during February through April.

Water temperatures during the egg incubation and fry emergence were generally below the preferred range throughout most of the river, except during May when optimum temperatures were commonly exceeded (Figure 16).

NO. can go to 17-18 in March system

Steelhead fry and juvenile life stages rear in the lower Yuba River throughout the year, and therefore may experience the full range of temperature conditions that characterize the river. Generally, mean weekly maximum temperatures exceed preferred conditions at Marysville beginning in early April to mid-May for each year evaluated. The incipient upper lethal temperature is 75.0°F (Bell 1986). This temperature threshold was exceeded by the mean weekly maximum in the lower portion of the river from mid-June to early August in 1973, and from mid-June to early September in water years 1976 and 1977 (Table 13, Figure 16). From Englebright Dam to Marysville, temperature conditions exceeded the preferred range for each life stage from mid-May to September during water year 1973, mid-June to October in 1974, and October and mid-July to mid-August during 1975.

American Shad

Water temperature is an important habitat characteristic that partially determines the timing and strength of shad migrations into the river. The mean weekly maximum temperature near Marysville provides one measure of the probable effects of existing water temperature on shad. In water years 1973, 1976, and 1977, mean weekly maximum temperatures near Marysville were within the migration preferred temperature range for up to 4 weeks, then rose rapidly to temperatures that may have impaired migration (Table 13, Figure 16). The 1974, 1975, and 1978 water years provided suitable water temperature for longer periods.

In water years 1973, 1976, and 1977, mean weekly maximum temperatures near Marysville exceeded the preferred range throughout most of the spawning and incubation period (Table 13, Figure 16). The mean weekly minimum temperatures in this location generally remained within the preferred range. In 1974, 1975, and 1978, water temperatures throughout most of the river were within the preferred range during the spawning and incubation period.

No! No! No!!!
No prob

American shad fry and juvenile typically rear from May through November in the lower Yuba River. Under existing conditions, however, few young shad were in the river during 1976 through 1978. The fish observed were confined largely to areas near the confluence with the Feather River (Meinz 1979). The upper range of suitable water temperatures at 69.8°F was exceeded by the mean weekly maximum near Marysville during most of the summer rearing period in water years 1973, 1976, and 1977 (Table 13, Figure 16). However, the mean weekly minimum temperature near Marysville was largely in the preferred range. Painter et al. (1979) showed juvenile shad had completed emigration from the Feather River when water temperatures reached 59.9°F. In the years being considered, emigration could have occurred from late June to late September to early October.

ss
s to
sw

Water Temperature Modeling

SNTEMP was used to model and predict water temperatures for several meteorological and streamflow conditions in the lower Yuba River from Englebright Dam to its confluence with the Feather River at Marysville. The model allows the user to predict downstream temperatures as affected by changes in upstream discharges, water temperatures, stream geometry, and shading.

Meteorology

The meteorological data including mean daily air temperature, mean daily wind speed, percent mean daily relative humidity, and percent mean daily sunshine, were compiled from records accumulated at Beale Air Force Base.

Hydrology

Hydrology data, river discharge and water temperature, are required at major locations in the river system to balance heat accumulation and dispersal within the temperature model (Theurer et al. 1984). These significant locations, referred to as nodes, may also define where there is a known change in stream geometry, known discharge or thermal information to calibrate or validate the model, and as model simulation points monitored by the user. Table 14 contains a list by type and location of the major nodes used for this study.

Historical discharge data were collected from the USGS at: (1) Yuba River below Englebright Dam (Station 11418000), (2) Yuba River near Marysville (Station 11421000), (3) Deer Creek near Smartville (Station 11418500), and (4) Dry Creek near Browns Valley (Station 11420700). The first three sites were also sources for water temperature data. Additional, but limited, water temperature records were available for the Yuba River at Daguerre Point Dam (Station 11420800), and for Dry Creek. These records provided the initial data set for river flow and temperature at the various nodes within the study area.

Additional temperature data were collected in 1987 to complement existing historic data for those areas of the system that had incomplete information and to aid in calibration and validation of the temperature model. Seven locations were sampled. These are: (1) Deer Creek, 100 ft downstream of USGS Deer Creek gage; (2) the Narrows, Yuba River 6,000 ft downstream of Englebright Dam; (3) Highway 20, Yuba River at Highway 20 Bridge; (4) Dry Creek, 100 ft upstream of the confluence with the Yuba River; (5) Daguerre Point Dam, Yuba River 200 ft upstream of Daguerre Point Dam; (6) Hallwood, Yuba River 300 ft upstream of Hallwood Boulevard; and (7) Simpson Lane, Yuba River 300 ft downstream of Simpson Lane bridge crossing. Temperatures were recorded at 20 minute intervals (30 minute intervals at the Narrows) at these sites using Ryan TempMentor thermographs.

Table 14. List of major node types, distances, and locations downstream of Englebright Dam to the confluence with the Feather River, used in the instream water temperature model of the lower Yuba River, California, 1987.

Type of node	Distance (km/mi)	Location
Structure	0.0/0.0	Englebright Dam
Discharge*	1.9/1.2	Deer Creek confluence
Output and change	3.3/2.0	Mouth of the Narrows
Output and change	9.5/5.9	Highway 20 Bridge
Output and discharge	16.6/10.3	Dry Creek confluence
Output, change and diversion	20.2/12.5	Daguerre Point Dam
Output	24.5/15.2	Yuba Goldfields
Output and validation	28.5/17.7	USGS Gage near Marysville
Output and change	31.9/19.8	Marysville City Dump site
Change*	32.8/20.4	Backwater-Pool terminus
Output	35.6/22.1	Simpson Lane Bridge
End	38.5/23.9	Feather River confluence

* Not a simulation site.

Transsects set random.

Stream Geometry

Stream geometry and riparian shading measurements were developed during the instream flow study. Measurement of average stream width and riparian vegetation shading were taken during habitat mapping activities. Elevation, gradient, distance, and topographic shading were determined from USGS quadrangle maps. The hydraulic retardance parameter was obtained from data collected for the instream flow study.

Model Calibration

Seven years of local meteorological and water temperature data (1972 through 1978, and 1987) were used to calibrate the water temperature model. The model was run on daily time intervals to

why? Review on daily basis.

achieve maximum use of the available data and to allow for the best model calibration. Daily values were averaged to generate monthly values. Individual months of data were analyzed and calibrated separately. Multiple, iterative runs were made to calibrate the simulated temperatures to the observed data. The calibration was primarily accomplished by adjusting the wind speed and air temperature coefficients. These adjustments were made to account for probable differences between conditions on the Yuba River and at Beale Air Force Base where the meteorological data were collected. A global wind speed coefficient of 0.80 was used for all months, while air temperature coefficients were varied by month, as follows:

April	-	1.120
May	-	1.092
June	-	1.084
October	-	1.127
November	-	1.387

These calibration adjustments minimized the mean errors of prediction to zero for all months, with an average correlation coefficient of 0.9476, average probable error of 0.69, average maximum error of 3.88, and average bias of 0.05 (Table 15). Sample sizes for each month varied between 150 and 200 daily data points, depending on the month and completeness of data.

Table 15. List of months and years used for calibration of the instream water temperature model, along with the statistical measures of model performance.

Month	Calibration Years	Correlation coefficient	Mean error (°C)	Probable error (°C)	Maximum error (°C)	Bias
April	1973-1978	0.9195	0.00	0.64	3.32	0.05
May	1973-1978	0.9565	0.00	0.62	3.59	0.05
June	1973-1978	0.9512	0.00	0.76	4.63	0.06
October	1973-1977 and 1987	0.9711	0.00	0.85	4.86	0.06
November	1972-1977 and 1987	0.9399	0.00	0.59	3.02	0.04
Mean		0.9476	0.00	0.69	3.88	0.05

After the individual months were calibrated, months representing warm, normal, and cool weather conditions were selected for simulation of the effect of climate on varying combinations of flow releases from Englebright Dam and diversions near Daguerre Point Dam. The months were chosen by comparing the mean monthly air temperatures for the months where flow and water temperature were available to a partial record of the mean monthly air temperatures at the Marysville Weather Station from 1948 through

1986, and the long-term (50-year) average. All available years of record were ranked by month on a temperature scale using the average temperature for the month. The months in the frequency analysis were then characterized as warm, normal, and cool years if they fell in the upper, middle, or lower portions of the scale, respectively. Representative warm, normal, and cool months from the years 1972 through 1978 were then selected from the frequency analysis for simulation (Table 16).

Table 16. List of months and years of data used for simulating warm, normal, and cool meteorological conditions, lower Yuba River, California.

Month	Warm	Normal	Cool
April	1977	1978	1975
May	1973	1975	1977
June	1973	1976	1978
October	1976	1977	1975
November	1976	1977	1972

Temperature Simulation

OK

April, May, June, and October and November were simulated. The winter months (December through March) and summer months (July through September) were not simulated due to limited funding.

Water temperatures were evaluated over a range of flow conditions above and below Daguerre Point Dam during warm, normal, and cool weather conditions for the selected months. Flows above Daguerre Point Dam are largely determined by the releases from Englebright Dam, flows below Daguerre Point Dam are largely determined by the magnitude of diversions in the vicinity of the dam. The flows evaluated include 245/245 cfs (above/below Daguerre Point Dam with no diversion); 400/400 cfs (no diversion); 745/245 cfs (500 cfs diversion); and 1,245/245 cfs, 1,500/500 cfs, 2,000/1,000 cfs, and 3,000/2,000 cfs with 1,000 cfs diversion.

Starting water temperatures for releases from Englebright Reservoir were derived from the 1972-1978 mean water temperatures recorded at the USGS Narrows gage below Englebright Dam. The mean values of observed daily mean water temperatures used in the simulations for each month were:

Too much variability
to presume average
starting temp.

Month		Temperature (°F)	
		Mean	Range*
April	-	48.9	46.4-50.0
May	-	53.1	51.4-57.6
June	-	57.9	54.5-63.5
October	-	53.1	46.4-59.9
November	-	48.9	42.8-55.0

* range not used in model

The maximum temperature change within the range modeled occurs in a warm June at a flow release of 245 cfs, when a starting temperature of 57.9°F increases to 78.6°F at Marysville (Figures 17-21). The ten simulation points on each curve correspond to those previously described in Table 14. Minimum change occurs in a cool November at 3,000 cfs release and 1,000 cfs diversion, when a starting temperature of 48.9°F becomes only 50.5°F at Marysville. The effect of water diversion at Daguerre Point Dam is most pronounced when either 500 or 1,000 cfs is diverted and 245 cfs passes downstream. Under these release/diversion conditions, the rate of temperature change increases significantly and often exceeds the temperature of a constant 400 cfs release with no diversion, by the time water reaches the Feather River.

Conclusions

Changes have occurred in water temperatures downstream of Englebright Dam as a result of increased storage capacity and dam operations following completion of New Bullards Bar Dam. Since completion of New Bullards Bar Dam, temperatures during early March through mid-June are warmer, early July through mid-December are generally cooler, and there are little differences in temperatures from mid-December through early March.

Potential effects of water temperatures on anadromous fish were assessed by comparing thermal preferences of each species life stage to existing temperature in the lower Yuba River during the 6 water years 1973 through 1978.

In spite of cooler temperatures during the summer and fall following the completion of New Bullards Bar Dam, temperature conditions for migrating fall-run chinook salmon at Marysville were near the upper range or exceeded the preferred range until after mid-October. Preferred spawning temperatures were exceeded at Marysville until mid-October 4 out of 6 years and until mid-November 3 out of 6 years evaluated. For many years, fry rearing temperatures are below optimum for portions of the river, while temperatures near Marysville begin to exceed preferred temperatures for juvenile rearing in most years by early April, and by June even water released from Englebright Dam exceeded the preferred range.

Temperatures for spring-run chinook salmon summer holding were in the preferred range during the summer of 1972-73 to 1977-78 water years in the Narrows Reach just below the Narrows 2 Powerhouse. During spring migration in dry years, high water temperatures at Marysville and associated low flows may be stressful and hinder access to the deeper pools of the Narrows Reach. However, temperatures in the Narrows Reach during most years exceed the preferred for spawning during September and for 2 of 6 years during October. Temperatures for egg incubation exceeded the preferred range during September and October for 3 out of 6 years evaluated.

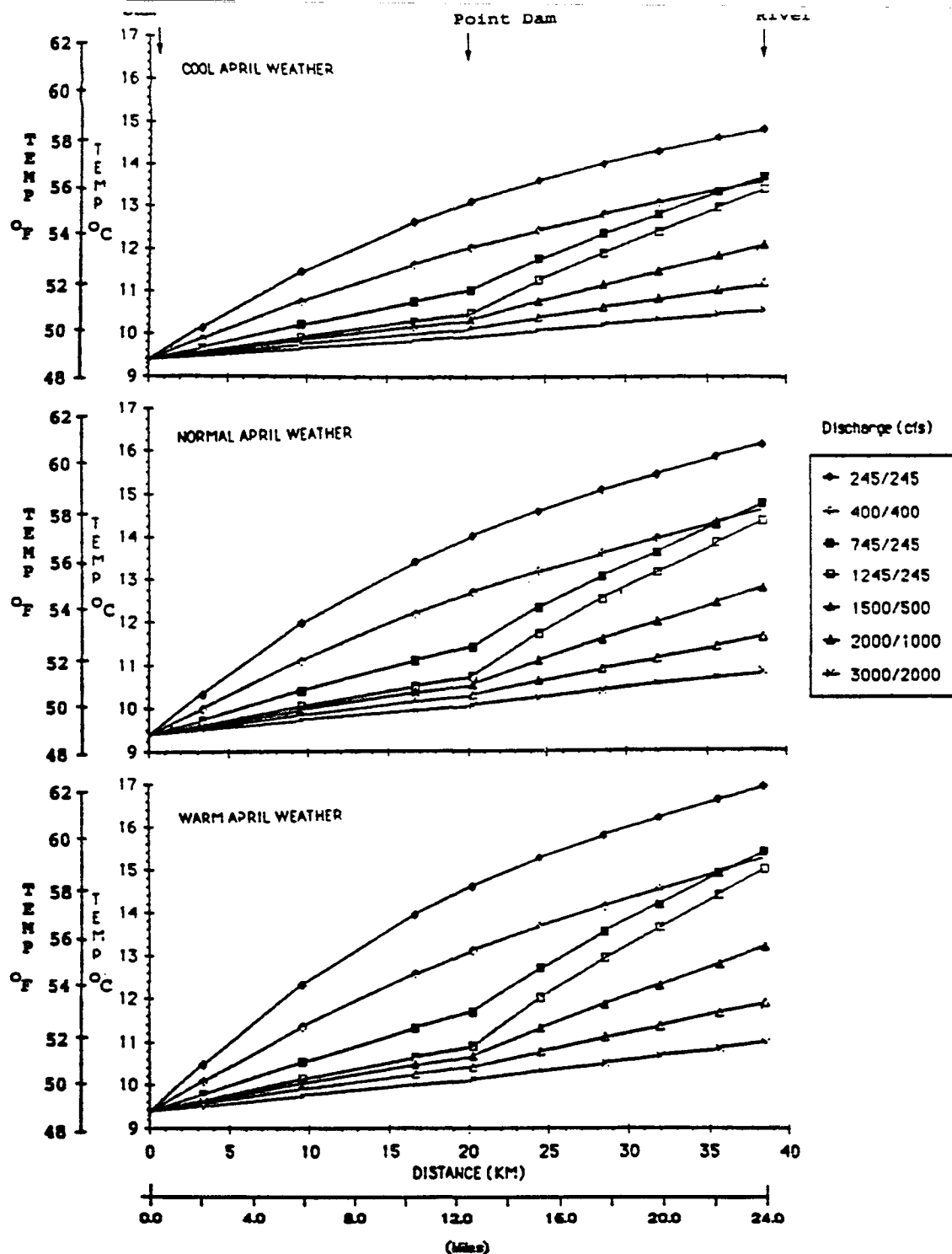


Figure 17. Simulated lower Yuba River, California, water temperatures for April weather. The alternative flow discharges evaluated are 245/245 cfs and 400/400 cfs (releases at Englebright Dam/below Daguerre Point Dam) with no diversion; 745/245 cfs with 500 cfs diversion; and 1,245/245 cfs, 1,500/500 cfs, 2,000/1,000, and 3,000/2,000 cfs with 1,000 cfs diversion.

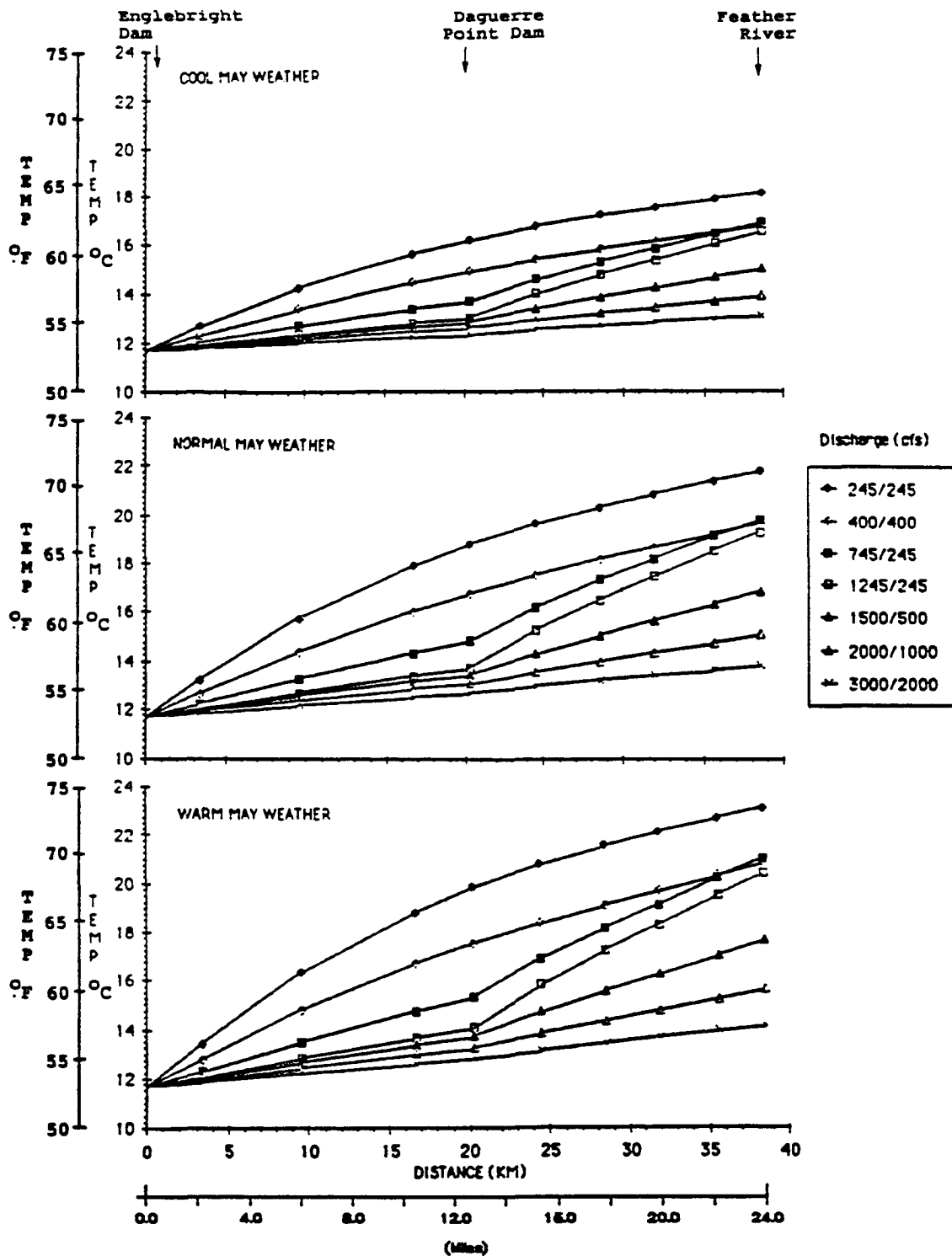


Figure 18. Simulated lower Yuba River, California, water temperatures for May weather. The alternative flow discharges evaluated are 245/245 cfs and 400/400 cfs (releases at Englebright Dam/below Daguerre Point Dam) with no diversion; 745/245 cfs with 500 cfs diversion; and 1,245/245 cfs, 1,500/500 cfs, 2,000/1,000, and 3,000/2,000 cfs with 1,000 cfs diversion.

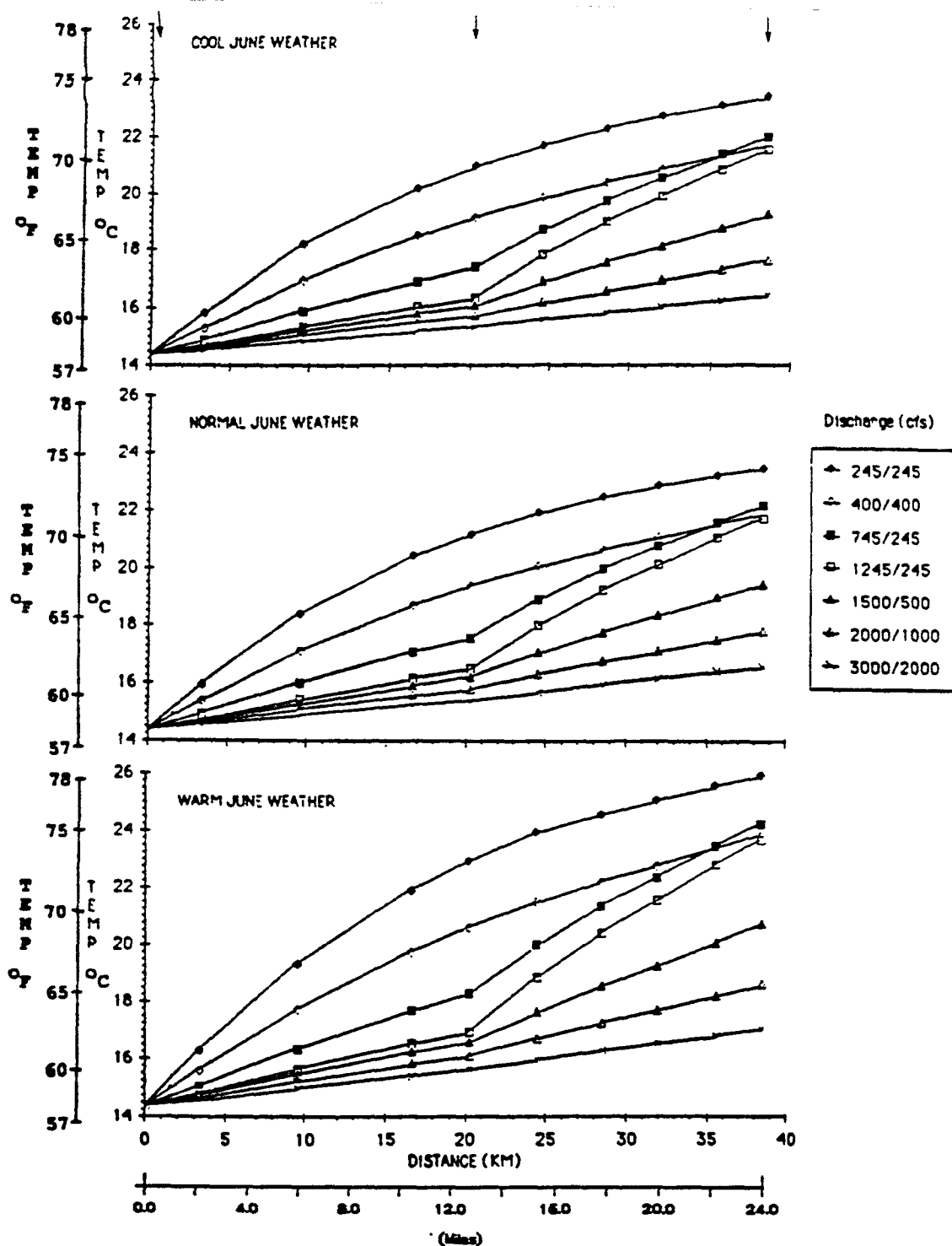


Figure 19. Simulated lower Yuba River, California, water temperatures for June weather. The alternative flow discharges evaluated are 245/245 cfs and 400/400 cfs (releases at Englebright Dam/below Daguerre Point Dam) with no diversion; 745/245 cfs with 500 cfs diversion; and 1,245/245 cfs, 1,500/500 cfs, 2,000/1,000, and 3,000/2,000 cfs with 1,000 cfs diversion.

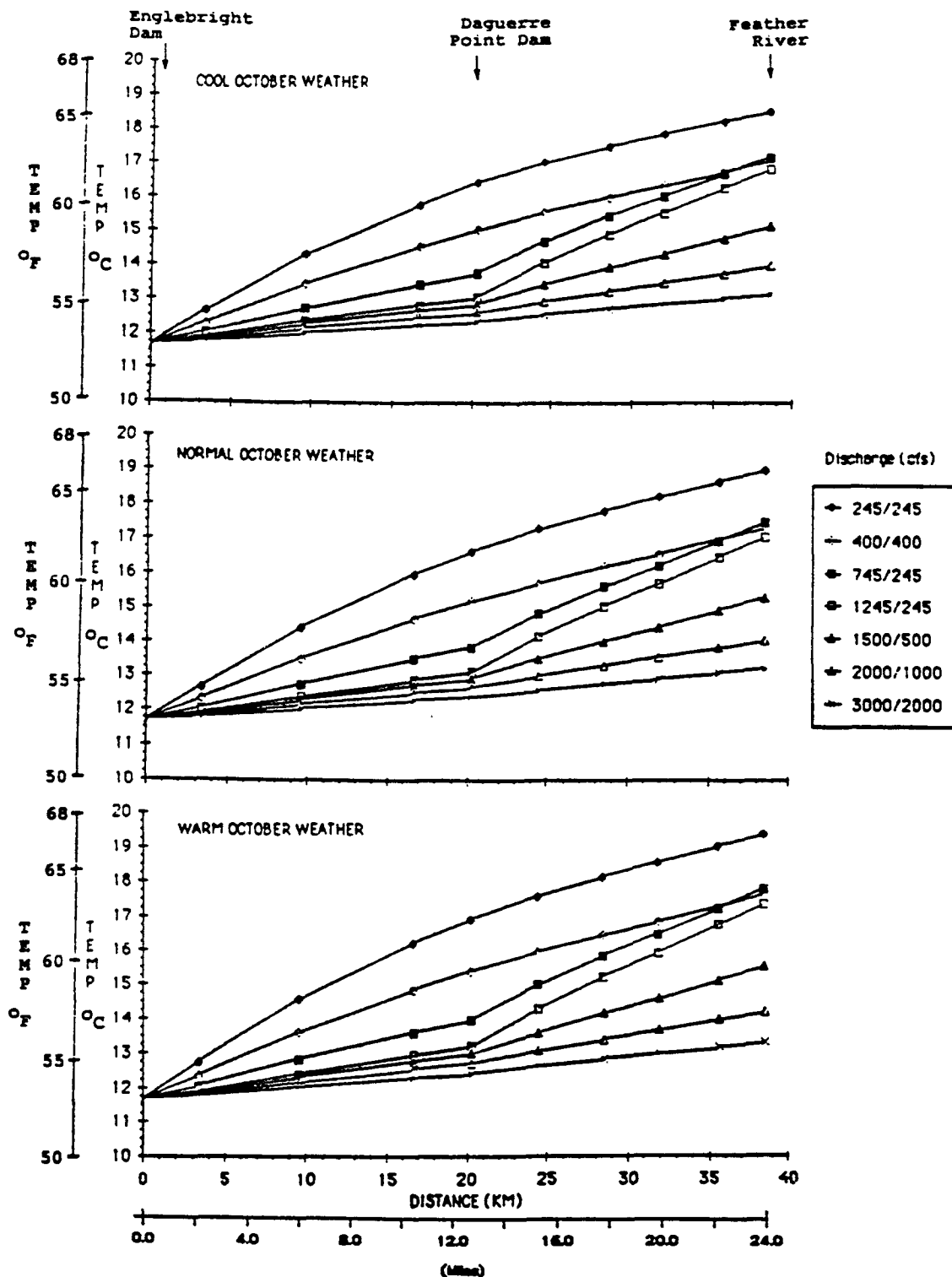


Figure 20. Simulated lower Yuba River, California, water temperatures for October weather. The alternative flow discharges evaluated are 245/245 cfs and 400/400 cfs (releases at Englebright Dam/below Daguerre Point Dam) with no diversion; 745/245 cfs with 500 cfs diversion; and 1,245/245 cfs, 1,500/500 cfs, 2,000/1,000, and 3,000/2,000 cfs with 1,000 cfs diversion.

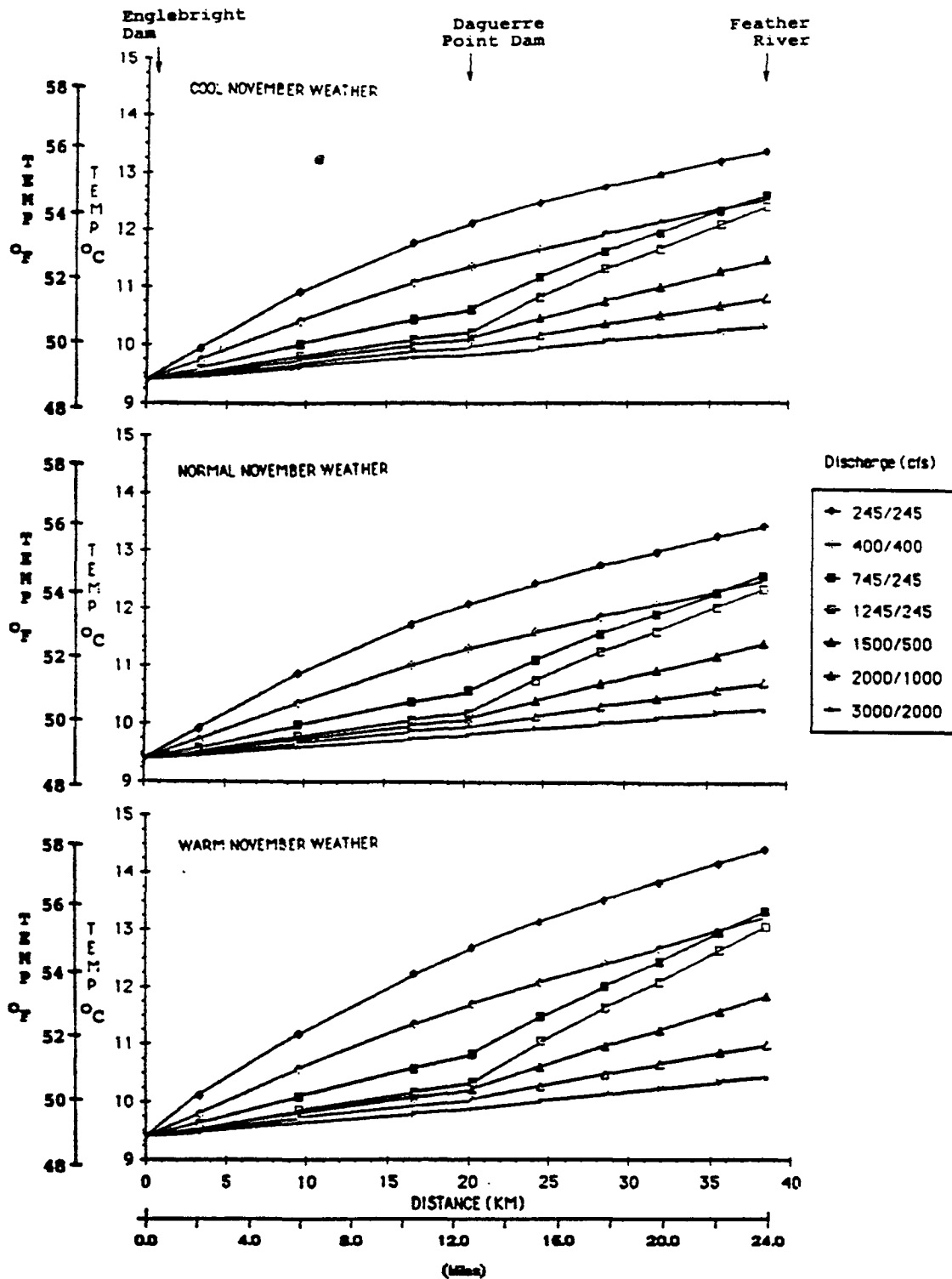


Figure 21. Simulated lower Yuba River, California, water temperatures for November weather. The alternative flow discharges evaluated are 245/245 cfs and 400/400 cfs (releases at Englebright Dam/below Daguerre Point Dam) with no diversion; 745/245 cfs with 500 cfs diversion; and 1,245/245 cfs, 1,500/500 cfs, 2,000/1,000, and 3,000/2,000 cfs with 1,000 cfs diversion.

The preferred temperatures for steelhead spawning migration were generally exceeded in the September and October period and were occasionally exceeded during November and early December. Minimum temperatures were within the preferred spawning range, however, maximum temperatures exceeded the preferred range. Egg incubation temperatures were generally below those preferred. Upper lethal temperatures for steelhead fry and juveniles were experienced during mid-June to September during 3 of the 6 years.

Temperatures preferred by American shad for migration were suitable for only a brief period (4 weeks or less) for 3 of the 6 years, rapidly rising to temperatures that may impair migration. For 3 out of 6 years, water temperatures throughout most of the river were within the preferred range during the spawning and incubation period. While preferred temperatures for shad fry and rearing were exceeded during most of the summer period for 3 out of 6 years.

Water temperature modeling indicates the greatest temperature change from Englebright Dam to Marysville occurs during a warm June at a flow release of 245 cfs. Minimum change occurs during a cool November at a 3,000 cfs release from Englebright Dam and 1,000 cfs diversion at Daguerre Point Dam. The effect of water diversion at Daguerre Point Dam is most pronounced when either 500 or 1,000 cfs is diverted and 245 cfs passes downstream. Under these conditions, the rate of temperature change increases significantly and often exceeds the temperature of a constant 400 cfs release from Englebright Dam, and no diversion, by the time water reaches the Feather River.

* * In the selection of temperature criteria, the goal is to maximize habitat conditions for each life stage of fall- and spring-run chinook salmon, steelhead, and American shad. Because fall- and spring-run chinook salmon are of value to both the sport and commercial interests, they are considered of primary importance in management of the lower Yuba River. Further, management decisions must be based upon the fact that chinook salmon and steelhead have the most similar temperature requirements and time of use of the river while American shad differ greatly in temperature requirements and times of use of the river. *No overlap w/ salmon & SH.*

Good
see deck
The primary anadromous ^{April} fish activity in the lower Yuba River from mid-October through ~~March~~ is chinook salmon and steelhead trout migration, spawning, egg incubation, and fry rearing. The area containing the greatest spawning habitat is the Garcia Gravel Pit Reach followed by the Daguerre Point Dam Reach. Water temperatures not exceeding the daily average of 56.0°F (Chambers 1956; Rich 1987) in the area from Englebright Dam to Daguerre Point Dam should provide the greatest benefits to spring- and fall-run chinook salmon during this period. This temperature criterion is consistent with the Basin Plan (5A) established by the State Water Resources Control Board for the Sacramento River between Keswick Dam and Hamilton City (RWQCB 1975) and the

recommendations of the Upper Sacramento River Fisheries and Riparian Habitat Advisory Council (1989) in its fisheries management plan for the Sacramento River between Keswick Dam and Red Bluff Diversion Dam. This will provide a measure of protection to steelhead that prefer cooler temperatures that do not exceed 52.0°F. Temperature increases downstream of Daguerre Point Dam should be minimal during this period creating little if any impacts to the Daguerre Point Dam Reach. Therefore, a daily average temperature of 57.0°F as measured at the Marysville gage should provide adequate protection to the Daguerre Point Dam Reach and Simpson Lane Reach.

I hope so.

During the period April through June, spring- and fall-run chinook salmon fry and juvenile rearing and outmigration are nearing completion, steelhead egg incubation and fry rearing continue, adult spring-run chinook salmon migration occurs, and American shad adult migration and spawning and fry rearing occur. The portion of the river where these activities primarily occur are found in the Garcia Gravel Pit Reach downstream to Marysville. To meet the requirements of these various species and life stages, temperatures at Marysville gage should not exceed the daily average of 60.0°F during April and May, and 65.0°F during June.

was "May and"

The July through mid-October period provides for the rearing of juvenile steelhead and American shad fry and juveniles, adult spring-run chinook salmon holding, and the upstream spawning migration of fall-run chinook salmon and steelhead begins. To meet the needs of these activities, the entire lower river is used during this period. Spring-run chinook salmon occupy the Narrows Reach where temperatures are coolest for summer holding in preparation for fall spawning. Steelhead rearing occurs from the Garcia Gravel Pit Reach downstream to Marysville, and American shad fry and juvenile rearing occurs from Daguerre Point Dam downstream to Marysville. Adult fall-run chinook salmon are entering the Yuba River from the Feather River beginning late September in preparation for spawning. To meet the various needs of these life stages, temperatures should not exceed the daily average of 65.0°F at Daguerre Point Dam during July and August and at the Marysville gage during September. During early to mid-October, temperatures at the Marysville gage should not exceed the daily average of 60.0°F.

How about 63-65 to get salmon out of river. Look at historical to get idea of when temps need to warm.

Daily maximum water temperatures should not exceed the daily average temperatures recommended above, by more than 2°F for more than 8 h in any 24-h period during any month of the year.

Results of temperature simulations indicate that flows of 1,000, 2,000, 1,500, 1,000 and 700 cfs at Marysville during a warm April, May, June, October, and November, respectively, will meet the above temperature criteria depending on diversion amounts at Daguerre Point Dam.

backhanded support of these flows.

* Additional temperature studies are needed to simulate the summer months of July through September similar to those completed for the months of April through June, October, and November. Other temperature studies should also be conducted on Englebright and New Bullards Bar reservoirs to develop information on temperature and water availability and integrate the findings with downstream evaluations. This additional evaluation should include simulations using a range of reservoir outlet temperatures from Englebright Reservoir for all months of concern. The reservoir cold water temperature studies should be conducted using a reservoir temperature model to: (1) predict the effects of altered operations on water temperatures downstream, (2) characterize reservoir elevations drawn upon by the intake structures, and (3) characterize the volume of cold water present in these reservoirs available to the intake structures.

Disagree. Surface area of total fish habitat, but it may or may not be composed of "optimal" habitat.

AQUATIC HABITAT AND STREAM DISCHARGE RELATIONSHIPS

Determining aquatic habitat and streamflow relationships are integral components in assessing fishery habitat needs and developing a management plan for the lower Yuba River. The computer based Instream Flow Incremental Methodology (IFIM)/Physical Habitat Simulation (PHABSIM) method (Bovee and Milhous 1978; Bovee 1982; Milhous et al. 1984) was applied to develop information on these relationships. The habitat-flow relationship developed by IFIM/PHABSIM is demonstrated as an index called weighted usable area (WUA). Changes in WUA represent changes in the availability of aquatic habitat. The WUA index is defined as the total wetted area of a stream reach expressed as an equivalent surface area of optimal fish habitat (Bovee and Milhous 1978). Application of IFIM/PHABSIM includes: (1) species composition and distribution identification; (2) selection or development of species habitat criteria; (3) stratification of the study area; (4) selection of aquatic habitat types and transects; (5) field data acquisition; (6) hydraulic and physical habitat modeling; and (7) interpretation of modeling results.

Application of IFIM/PHABSIM on the Lower Yuba River

The IFIM/PHABSIM methodology was applied on the lower Yuba River to evaluate habitat-stream discharge relationships for chinook salmon and steelhead trout. This method was also to be applied to develop information on American shad streamflow-habitat relationships. However, insufficient information was collected to complete the shad analyses.

A combined river segment/habitat mapping approach was used to apply the IFIM/PHABSIM complex on the lower Yuba River. The river was divided into similar segments based on hydraulic conditions, channel morphology and gradient, geology, water conditions, and fish species distribution. The type, abundance, and distribution of specific macrohabitat types within each river segment was then assessed and mapped. The hydraulic and physical characteristics of these habitat types were sampled and used to model the lower Yuba River's habitat-streamflow relationships. The IFG4 and Water Surface Profile models within the overall IFIM framework were used to develop a model of the hydraulic and physical characteristics. The resultant characteristics model and habitat criteria information included in the criteria section were combined through PHABSIM to develop information on species life stage habitat-discharge relationships. This information was then used to develop flow regimes which would optimize each species habitat.

The lower Yuba River was divided into four segments. These are:

- 1) **Narrows Reach:** Extending from Englebright Dam to the downstream terminus of the Narrows, this reach consists of 11,400 ft of river with steep-walled canyon

topography, dominated by deep pools, and bedrock and large boulder substrate. Of the four river sections this reach has the highest gradient. The dominance of the deep pools makes this reach an important site for spring-run chinook salmon holding during late-spring, summer, and fall. This reach is relatively unimportant for spawning or rearing fall-run chinook.

- 2) Garcia Gravel Pit Reach: This reach consists of 56,400 ft of the lower Yuba River from the Narrows downstream to Daguerre Point Dam. It is typified by repeating segments of long, deep pools, shallow pools, run/glide, and long low-gradient riffles. Substrate composition is primarily a combination of boulders, cobbles, and gravel and is highly suited for spawning chinook salmon. The river banks are often composed of placer mining tailings 30 to 50 ft high. Occasional side channels, which are frequently dry, cut in and out of the main channel. Some riparian vegetation exists but in most cases it is too far away to shade the river.
- 3) Daguerre Point Dam Reach: This 41,400-ft reach extends from Daguerre Point Dam to the upstream terminus of the backwater influence of the Feather River. The characteristics of the stream are similar to the Garcia Gravel Pit Reach, except there are fewer riffles and more pools. This reaches' riverine morphology, habitat sequence, substrate composition, and riparian habitat are also similar to that of the Garcia Reach. This reach has good spawning and rearing potential for chinook salmon, and for American shad spawning and early life stages.
- 4) Simpson Lane Reach: Beginning at the upstream end of the Feather River backwater and extending to the confluence with the Feather River, this 18,500-ft reach is a low gradient and low velocity stretch of the Yuba River. It is characterized by deep pool habitat subject to the backwater influence of the Feather River. Steep river banks, man-made levees, and a tall riparian corridor on each bank typify this portion of the river. The substrate is hardpan, bedrock, or sand, and has limited potential for chinook spawning but is known to provide rearing for juvenile American shad.

Habitat Mapping

The habitat mapping approach was used to determine the type, abundance, and distribution of macrohabitats available within each of the four study segments described above. Representatives of each macrohabitat type were selected for subsequent sampling. The measured microhabitat information was used to model and predict

habitat availability at different flows. This information was expanded with respect to the proportional availability of each specific macrohabitat to represent the lower Yuba River. A preliminary review indicated that lower Yuba River macrohabitats typically fell within five major categories. These are:

- 1) Low Gradient Riffle: These riffles are low gradient (0-2%) and contain little or no white-water, but have a fairly uniform choppy water surface. Mean column velocity generally exceeds 2 ft/s and depth is generally less than 2 ft.
- 2) Moderate Gradient Riffle: These riffles generally have a moderate or high gradient (>3%), usually contain white-water, standing waves, and/or possibly a series of waterfalls.
- 3) Run/Glide: Run/glide habitats are generally deeper and of lower gradient than low gradient riffle. They typically have a fairly smooth water surface and a mean column velocity generally in excess of 2 ft/s.
- 4) Shallow Pool: These pools are less than 4 ft deep with a mean column velocity less than 2 ft/s.
- 5) Deep Pool: Deep pools are deeper than 4 ft and have a mean column velocity less than 2 ft/s.

The entire study area was traversed by foot or kayak, and macrohabitat occurrence and length were determined. The proportional abundance of each macrohabitat type within intervals of 100 ft was developed from this information. Discharge above Daguerre Point Dam was 634, 735 and 623 cfs on October 22, 23, and 24, 1986, respectively, when the river was mapped. Below Daguerre Point Dam, flows for the respective days were 425 to 482 cfs. Results of habitat mapping for each reach of the study area are presented in Table 17. The Narrows Reach is composed almost entirely of deep pool (77%). Run/glide habitat (48%) dominates the Garcia Gravel Pit Reach, followed by low gradient riffle (24%), deep pool (15%), and shallow pool (13%). The Daguerre Point Dam Reach is also mostly run/glide habitat (41%), but contains relatively more deep (21%) and shallow pool (23%) than the Garcia Gravel Pit Reach. The Simpson Lane Reach habitat is dominated by deep pool (72%), with lower amounts of shallow pool (15%), run/glide (11%), and low gradient riffle (2%).

Transect Selection

* Transects for sampling water depth and velocities, substrate composition, and fish cover characteristics within macrohabitats were subjectively assigned to each of the four study reaches in proportion to the habitat types present in each reach. Transects were ground-truthed and placed on January 20 and March 12, 13, and

↳ They weren't randomly selected
in the ISI place -67-

biased toward spawners.
Should not use to extrapolate

23, 1987. Six transects were placed in the Narrows Reach, nine in the Garcia Gravel Pit Reach, seven in the Daguerre Point Dam Reach, and nine in the Simpson Lane Reach, for a total of 31 transects (Table 17). Special effort was made in low gradient riffle and run/glide habitat types to transect areas where chinook salmon had been observed spawning or where evidence of redds was still present. Remaining transects were placed where they would best characterize the type of micro- and macrohabitat they represented. Only deep pool habitat was represented by transects in the Narrows Reach since no other habitat type comprised greater than 10% of the reach.

Table 17. Habitat categories, distances, and number of transects in the lower Yuba River, California, study area by study reach.

Study reach	Macrohabitat category	Distance (ft)	Number of transects
Narrows	Low Gradient Riffle*	950	0
	Moderate Gradient Riffle*	650	0
	Run/Glide*	925	0
	Shallow Pool*	100	0
	Deep Pool	<u>8,775</u>	<u>6</u>
	Total	11,400	6
Garcia Gravel Pit	Low Gradient Riffle	13,625	2
	Run/Glide	26,825	2
	Shallow Pool	7,400	2
	Deep Pool	<u>8,550</u>	<u>3</u>
	Total	56,400	9 in 10.7 miles
Daguerre Point Dam	Low Gradient Riffle	6,175	2
	Run/Glide	17,075	2
	Shallow Pool	9,375	2
	Deep Pool	<u>8,775</u>	<u>1</u>
	Total	41,400	7 in 7.8 miles
Simpson Lane	Low Gradient Riffle	400	1
	Run/Glide	2,100	2
	Shallow Pool	2,800	2
	Deep Pool	<u>13,200</u>	<u>4</u>
	Total	18,500	9
Grand total		127,700	31 in 24 miles

* No transects were placed to represent these habitat types since they comprised a small portion of the total reach.

1 transect / 4,000 ft of stream.
Narrows + Simpson Lane - 15 transects (48%)
-68- in 5.6 miles (23%) of total habitat.

Data Collection

Water depths and mean column velocities were measured at each transect following the guidelines of Trihey and Wegner (1981) and Milhous et al. (1984) (Table 18). A minimum of 20 wetted stations per transect was established. The boundaries of each station along each transect were normally at even increments, but significant changes in water depth, velocity, substrate, or other important stream habitat features occasionally required additional stationing.

Total water depth was measured to the nearest 0.05 ft with a top-setting wading rod. Mean column velocity was measured 0.6 of the distance from the surface in depths less than 2.5 ft. In water between 2.5 and 4.0 ft deep, water velocities were measured at 0.2 and 0.8 of the total water depth and averaged to obtain mean column velocity (Buchanan and Somers 1969). Velocities at 0.2, 0.6, and 0.8 were measured and averaged in depths greater than 4.0 ft, or where the velocity distribution in the water column was inconsistent. A top-setting wading rod was used in water up to 6.0 ft deep. In depths greater than 6.0 ft, a boat, boom and sounding weight were used to lower the velocity meter to the proper depth. In deep pools where the majority of depths were greater than 6.0 ft, only bottom profile and water surface

Table 18. Streamflows measured by study reach and transect for instream flow computer model calibration, lower Yuba River, California.

No-Velocity Transects	Study reach	Transect	Flow levels (cfs)	Data type
6-all deep pools	Narrows	Transects 1-4	1,035/640/265	Stage and discharge
		Transects 5-6	1,030/615/255	Stage and discharge
3-all deep pools	Garcia	Transects 1-5	1,035/640/265	Depth and velocity
	Gravel Pit	Transects 6-8	1,035/640/265	Stage and discharge
		Transect 9	1,035/640/265	Depth and velocity
1-deep pool	Daguerre Point Dam	Transects 1-6	630/218/180	Depth and velocity
			1,054/35	Stage and discharge
		Transect 7	630/218/180	Stage and discharge
			1,054/35	Stage and discharge
4 all deep pool	Simpson Lane	Transects 1-5	830/300/197	Depth and velocity
			1,027/84	Stage and discharge
		Transects 6-9	830/300/197	Stage and discharge
			1,027/84	Stage and discharge

H

Of 31 transects, 14 had no velocity measurements at all!
(14 of 14 pools).

Pg 28 says this habitat has greatest densities of salmon trout

elevation data were collected. Mechanical, rotating-cup Price AA and Montedoro-Whitney PVM-2A electromagnetic water velocity meters were used to measure velocities.

Measurements required to calibrate the instream flow computer models were made from March through August, 1987. Water depths and velocities were measured at stations along each transect in all non-deep pool habitats at three stream discharges. River stage and discharge were measured at all transects at the three stream discharges. Additional river stage and discharge measurements were taken at Daguerre Point Dam and Simpson Lane to extend the data extrapolation range for these study reaches. Additional stage-discharge data were not collected above Daguerre Point Dam because the high flows upstream were high enough to cover the upper flow range of interest. Lower flow measurements upstream of Daguerre Point Dam were not possible due to high releases. However, these measurements were not needed to cover the lower flow range of interest.

Data Analysis

The one-flow option of the IFG4 model was employed to simulate depths and velocities at those transects where station water depths and velocities were measured. Data from the highest discharge measured were specified as the starting calibration data set. The IFG4 no-velocity option was used on the deep pool transects where station velocities were not measured due to depth and very low water velocities. With this option, deep pool velocities are simulated by allowing the model to distribute discharge across all cells on the basis of depth and a specified Manning's N value. Calibration modifications were limited to a few shallow edge cells that were allowed to "float" with a zero specified velocity, a change which gives more accurate results over a range of flows.

The Narrows, Daguerre Point Dam, and Simpson Lane reach data sets were analyzed with five-point stage-discharge rating curves and water surface elevation data taken from the program WSEI4S, without the mass-balance option of IFG4. The Garcia Gravel Pit Reach data set was analyzed with internal three-point stage-discharge rating curves with the mass-balance IFG4 option. Mean errors of the transect rating curves were all within the acceptable value of 10% or less and most were 5% or less.

The velocity adjustment factors (indicators of simulation quality and acceptable range of extrapolation) for all flows simulated were within standard one-flow limits of 0.1 to 10.0. Total range of flows simulated for the Daguerre Point Dam and the Simpson Lane study reaches were 50 cfs to 2,500 cfs. Stage rating data could not be extrapolated to 50 cfs for those transects above Daguerre

Point Dam. Thus, the range of simulated flow for reaches upstream of Daguerre Point Dam, and the total lower river is limited to between 100 and 2,500 cfs.

Transect Weighting and Analysis — *Critical - should we verify calculations? NO.*

Results from each of the 31 transects (in WUA per 1,000 ft of stream) were compiled into macrohabitat, reach, and river totals. Weighting factors for expansion of transect data were derived from the linear distance of the habitat types measured within each of the four reaches. Total length of each macrohabitat type within each reach was divided by the number of transects placed in each habitat type. These factors were used to expand transect WUA information to estimate macrohabitat and then reach WUA. Total WUA for the entire river was generated by summing the results from the four reaches, thereby incorporating the length of river they each represent (i.e., 8,775 ft for the Narrows, 56,400 ft for Garcia Gravel Pit, 41,400 ft for Daguerre Point Dam, and 18,500 ft for the Simpson Lane reach). The results of these compilations are contained in Appendix II for chinook salmon and Appendix III for steelhead trout.

Fall- and Spring-Run Chinook Salmon

Spring-run chinook salmon were not modeled specifically, however, the results of studies of Yuba River fall-run chinook salmon are assumed to apply and to better meet the needs of Yuba River spring-run than those published in the literature. **NEW**

The WUA indices generated by the analyses indicate that the greatest amount of chinook salmon fry habitat is available in the lower Yuba River at a flow of 100 cfs (Figure 22). The flow providing the most habitat for chinook juveniles is between 150 and 200 cfs. Five hundred to 700 cfs provides the greatest amount of WUA for spawning salmon.

Separation of the components that create the total river WUA show the contribution of each study reach and habitat type. Chinook salmon fry WUA by study reach illustrates that the peak at 100 cfs is consistent in the Garcia Gravel Pit, the Daguerre Point Dam, and the Simpson Lane reaches while the value is highest at 300-cfs in the Narrows Reach (Figure 23). For each of the habitat types, WUA peaks at 100 cfs (Figure 23).

Chinook salmon juvenile WUA is most abundant near 200 cfs in the Daguerre Point Dam and Simpson Lane reaches and stays at about the same level between 100 and 350 cfs in the Garcia Gravel Pit Reach (Figure 24). Separation into habitat type shows that run/glide has the highest juvenile WUA at a flow of 200 cfs (Figure 24).

WUA for spawning chinook salmon shows somewhat more variation in response to changes in reach than fry or juvenile WUA. In the

Garcia Gravel Pit and Simpson Lane reaches, the peak in WUA occurs at 700 cfs, but the WUA peaks at 450-500 cfs in the Daguerre Point Dam Reach (Figure 25). Spawning WUA peaks at 400 cfs in low gradient riffles, at 700 cfs in run/glides, at 900 cfs in shallow pools, and is barely present in deep pools (Figure 25).

Most WUA for all chinook salmon life stages is found in the Garcia Gravel Pit and the Daguerre Point Dam reaches. Comparing these two reaches, the Garcia Gravel Pit reach provides the most WUA for the juvenile and spawning life stages while the two reaches provide roughly comparable amounts of fry habitat.

Steelhead Trout

The greatest amount of steelhead fry WUA in the lower Yuba River occurs between 100 and 200 cfs (Figure 26). For steelhead juveniles, the flows providing the most habitat range from 200 to 350 cfs. Six-hundred to 800 cfs provides the greatest amount of WUA for spawning steelhead.

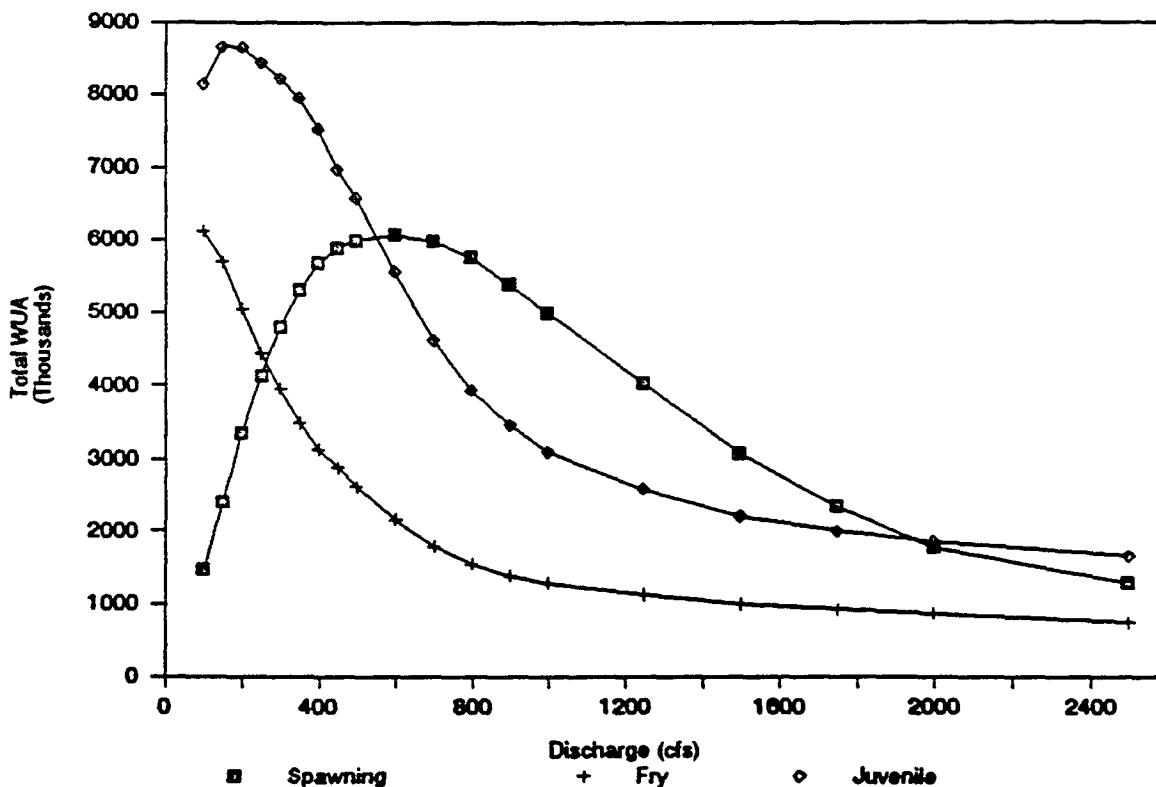


Figure 22. Chinook salmon spawning, fry, and juvenile WUA/stream discharge relationships in the lower Yuba River, California.

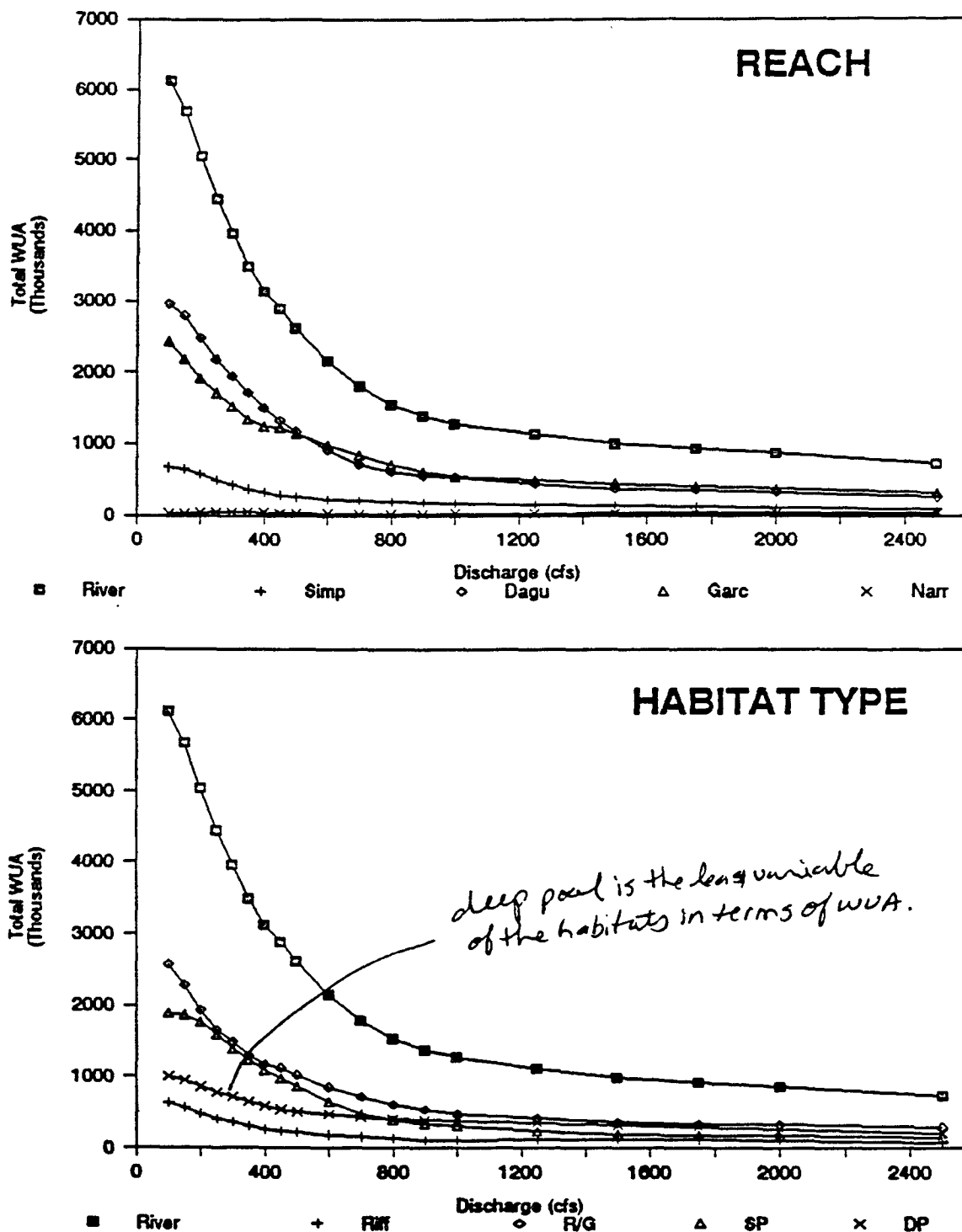


Figure 23. Chinook salmon fry WUA/stream discharge relationships for the Simpson Lane (Simp), Daguerre Point Dam (Dagu), Garcia Gravel Pit (Garc), and Narrows (Narr) study reaches, and for the riffle (Riff), run/glide (R/G), shallow pool (SP), and deep pool (DP) habitat types in the lower Yuba River, California.

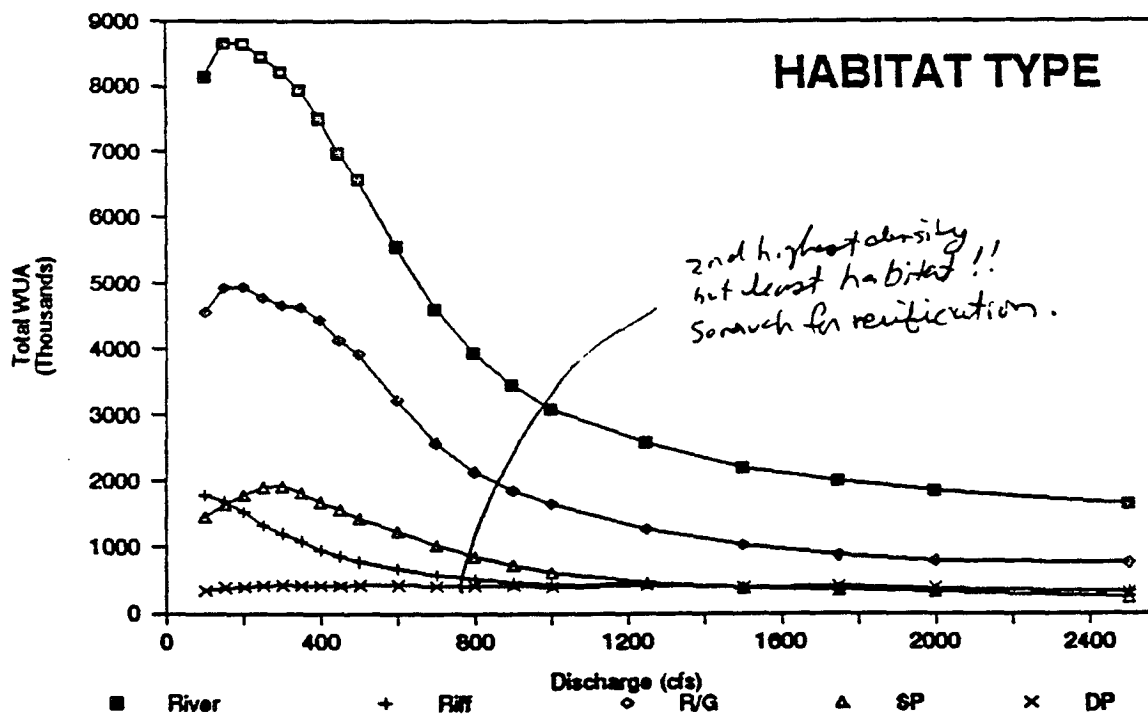
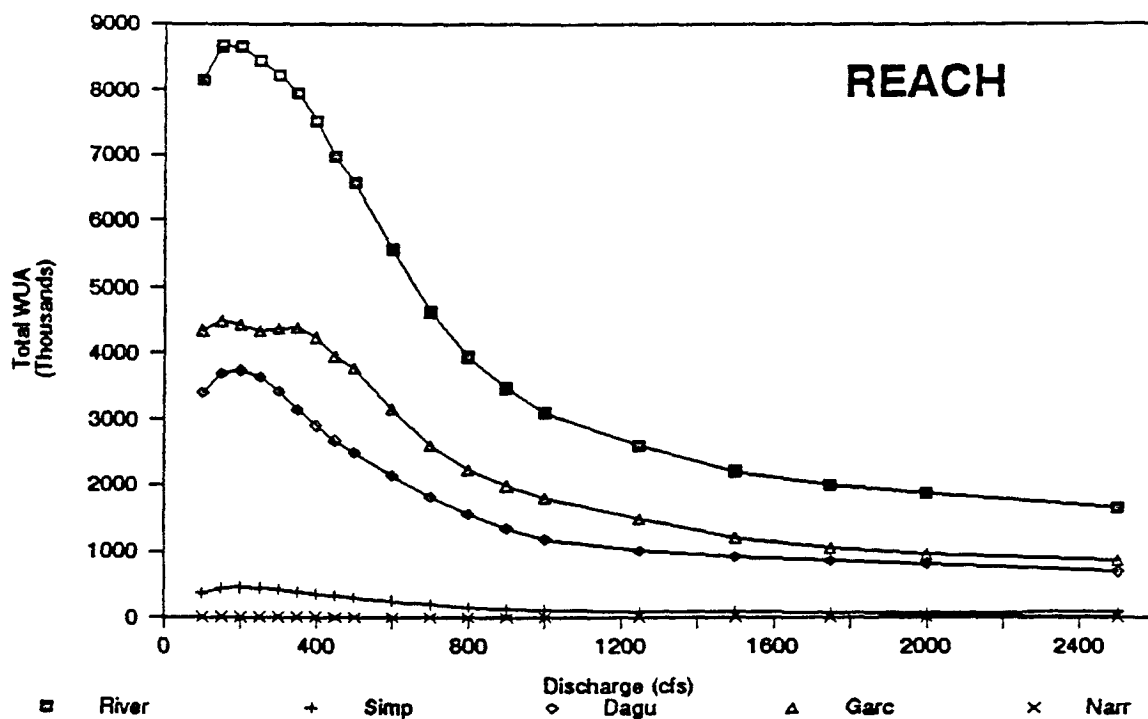


Figure 24. Chinook salmon juveniles WUA/stream discharge relationships for the Simpson Lane (Simp), Daguerre Point Dam (Dagu), Garcia Gravel Pit (Garc), and Narrows (Narr) study reaches, and for the riffle (Riff), run/glide (R/G), shallow pool (SP), and deep pool (DP) habitat types in the lower Yuba River, California.

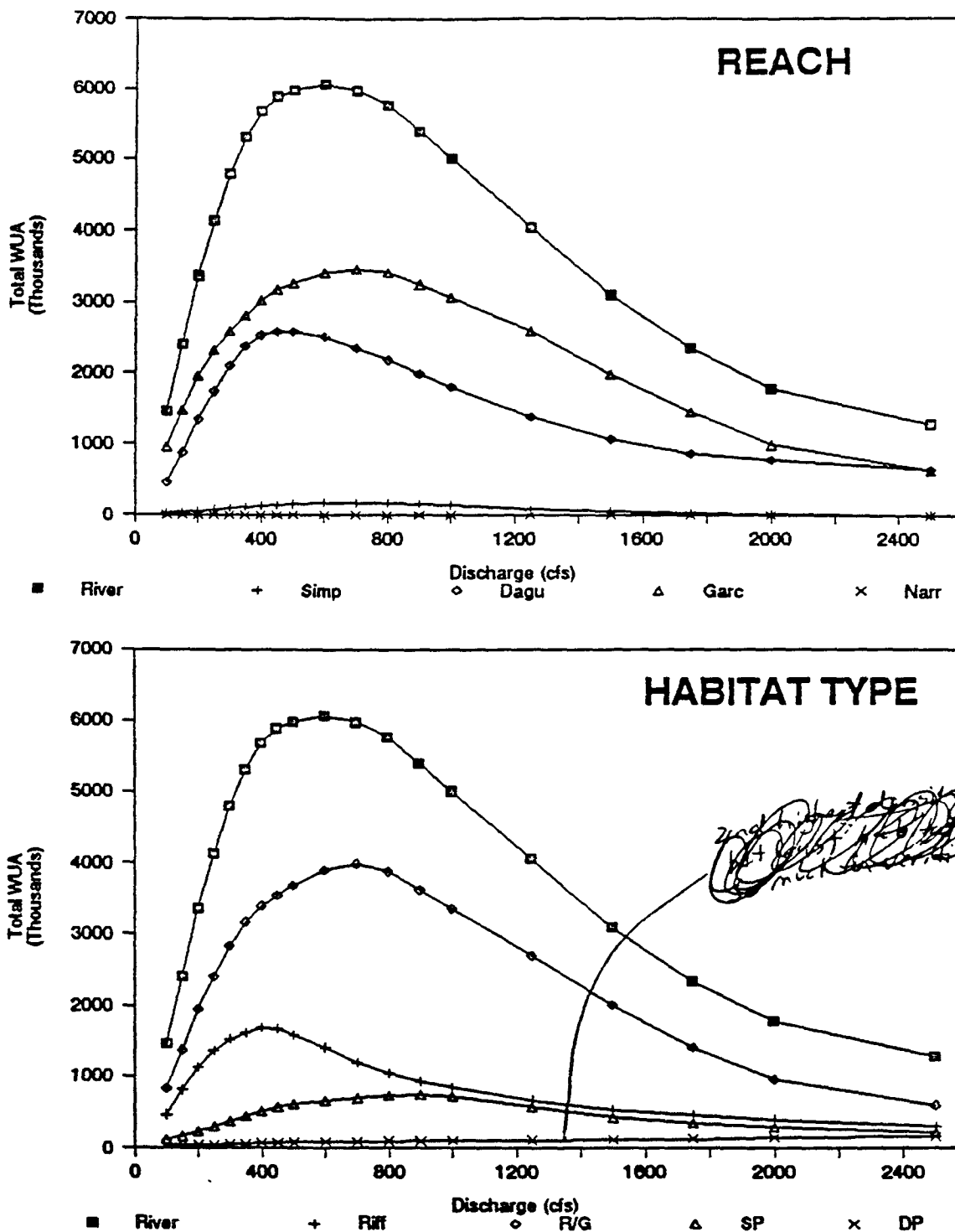


Figure 25. Chinook salmon spawning WUA/stream discharge relationships for the Simpson Lane (Simp), Daguerre Point Dam (Dagu), Garcia Gravel Pit (Garc), and Narrows (Narr) study reaches, and for the riffle (Riff), run/glide (R/G), shallow pool (SP), and deep pool (DP) habitat types in the lower Yuba River, California.

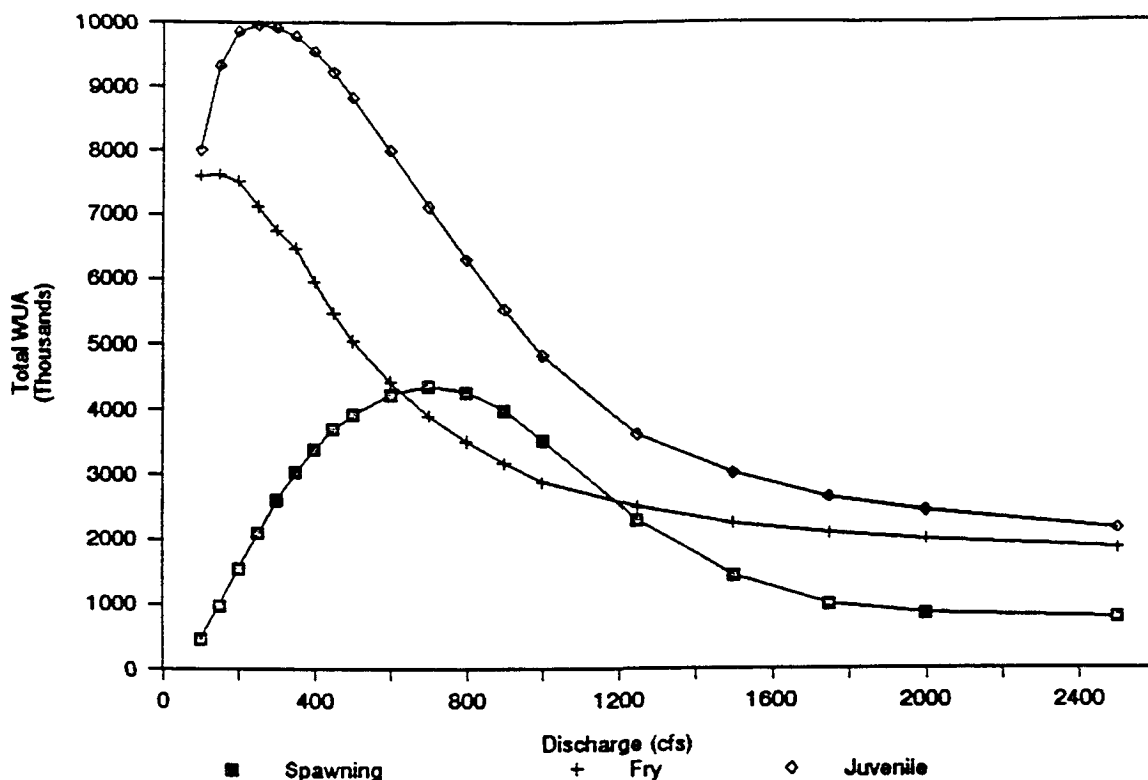


Figure 26. Steelhead trout spawning, fry, and juvenile WUA/stream discharge relationships in the lower Yuba River, California.

Separation of the components that create the river total WUA show the contribution to the total of each study reach and habitat type. Peak steelhead fry WUA occurs at 100 cfs in the Garcia Gravel Pit Reach, 150 cfs in the Daguerre Point Dam Reach, and 250 to 500 in the Simpson Lane Reach (Figure 27). The most steelhead fry habitat occurs at 900 to 2,000 cfs in the Narrows Reach. Run/glide habitat provides the majority of habitat, and WUA peaked at 100 to 200 cfs in this habitat type (Figure 27). Deep pools provide the least amount of fry habitat.

Juvenile steelhead WUA is greatest at 200 to 450 cfs in the Garcia Gravel Pit and Daguerre Point Dam reaches (Figure 28). The majority of juvenile steelhead habitat in the lower Yuba River is found in these two reaches. Run/glide habitat has the highest juvenile WUA at a flow of 250 to 450 cfs (Figure 28). Run/glide and shallow pool habitat types comprised the majority of the juvenile WUA. Deep pools and riffles comprised the least amount of the WUA.

WUA for spawning steelhead peaks at 700 to 800 cfs in the Garcia Gravel Pit Reach, 450 to 500 cfs in the Daguerre Point Dam Reach, and 600 to 900 cfs in the Simpson Lane Reach (Figure 29). No spawning habitat is available at any flow in the Narrows Reach. Run/glide habitat provides substantially more spawning than do the

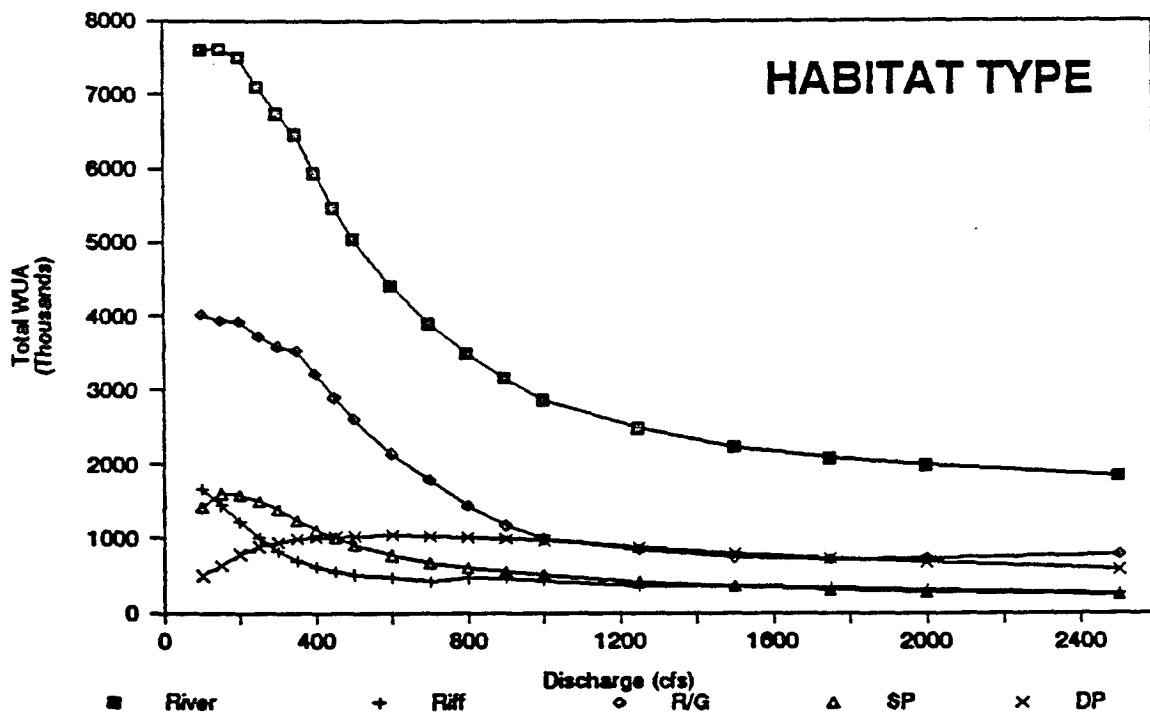
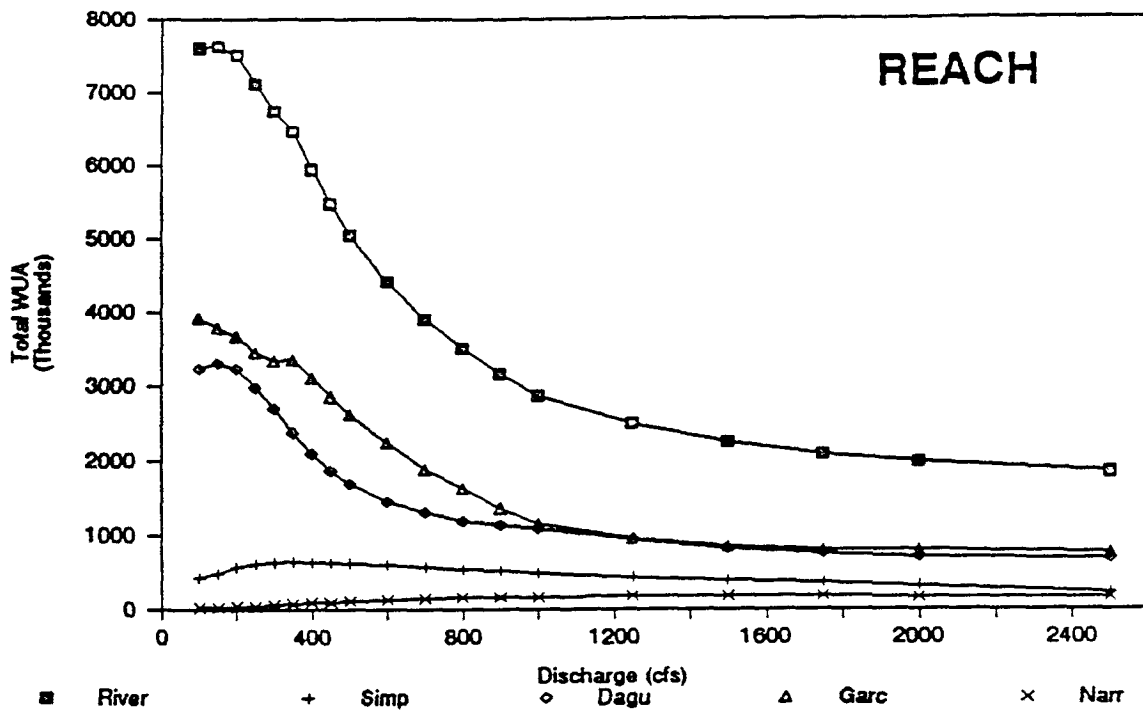


Figure 27. Steelhead trout fry WUA/stream discharge relationships for the Simpson Lane (Simp), Daguerre Point Dam (Dagu), Garcia Gravel Pit (Garc), and Narrows (Narr) study reaches, and for the riffle (Riff), run/glide (R/G), shallow pool (SP), and deep pool (DP) habitat types in the lower Yuba River, California.

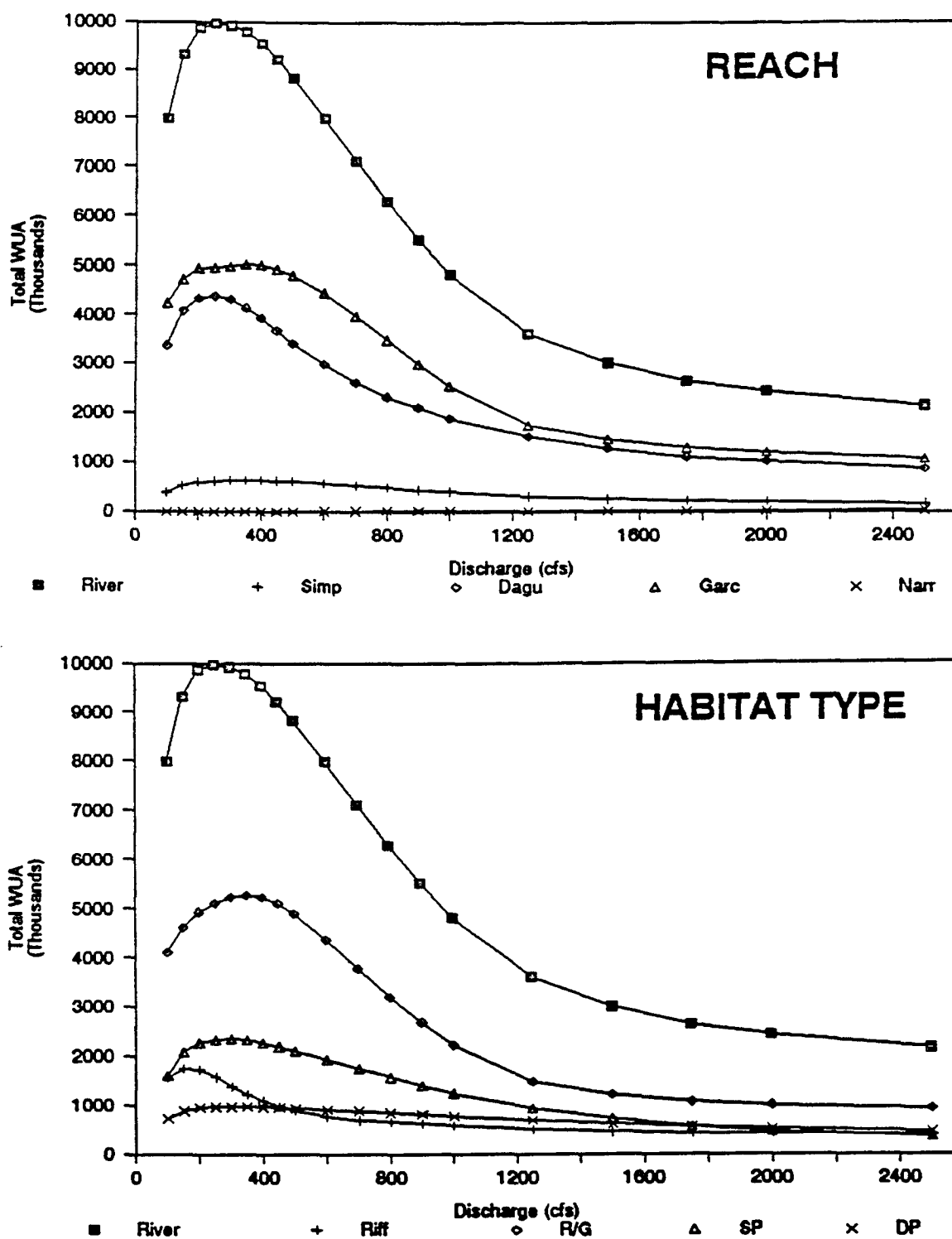


Figure 28. Steelhead trout juvenile WUA/stream discharge relationship for the Simpson Lane (Simp), Daguerre Point Dam (Dagu), Garcia Gravel Pit (Garc), and Narrows (Narr) study reaches, and for the riffle (Riff), run/glide (R/G), shallow pool (SP), and deep pool (DP) habitat types in the lower Yuba River, California.

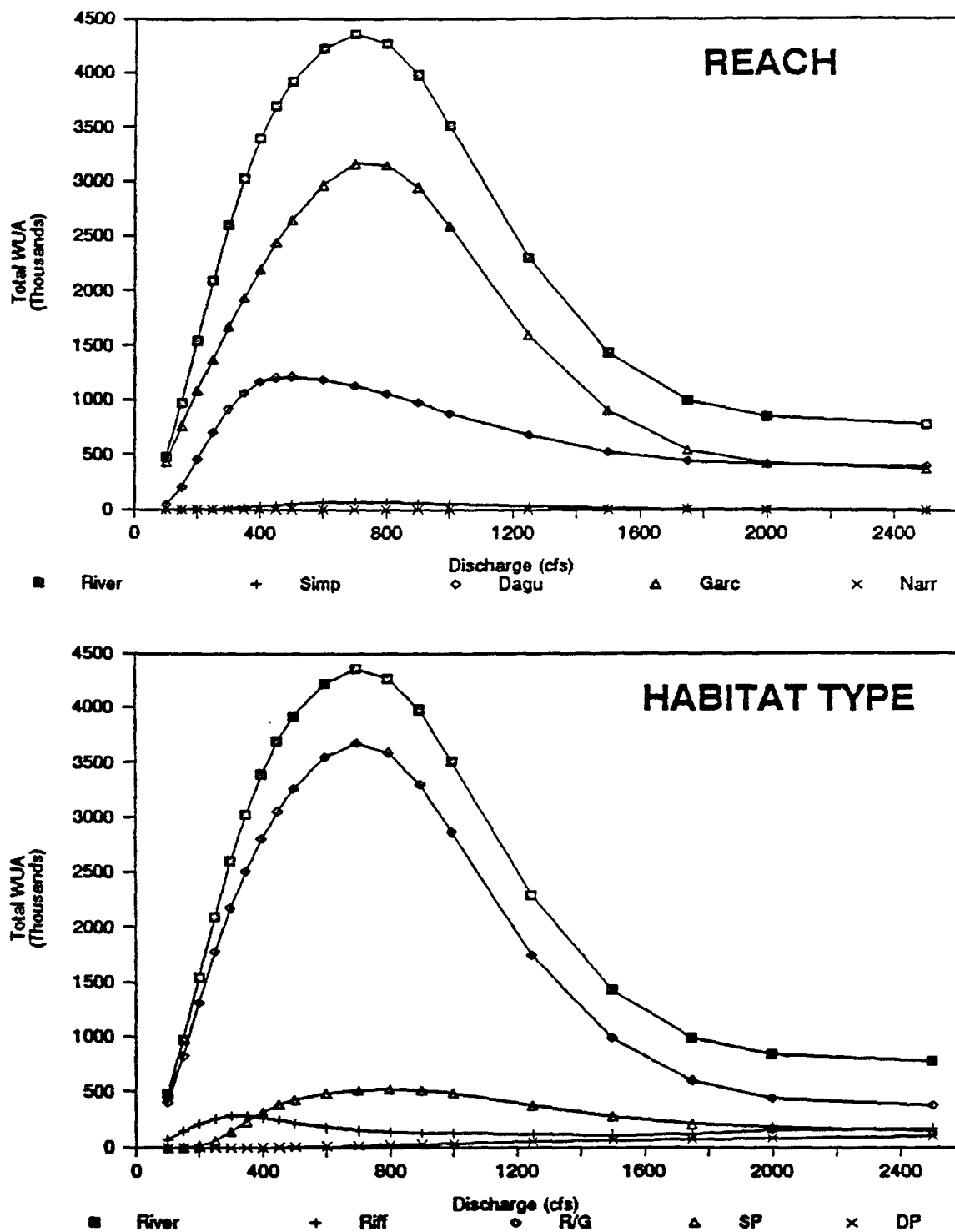


Figure 29. Steelhead trout spawning WUA/stream discharge relationships for the Simpson Lane (Simp), Daguerre Point Dam (Dagu), Garcia Gravel Pit (Garc), and Narrows (Narr) study reaches, and for the riffle (Riff), run/glide (R/G), shallow pool (SP), and deep pool (DP) habitat types in the lower Yuba River, California.

other habitat types (Figure 29). Run/glide habitat provided the greatest habitat at a flow of 600 to 800 cfs.

Separating the lower Yuba River into reaches with all macrohabitats combined indicates that for all life stages of steelhead trout, the greatest WUA is found in the Garcia Gravel Pit and Daguerre Point Dam reaches. Of the two reaches, the Garcia Gravel Pit reach provides the most WUA for all stages, particularly for spawning.

American Shad

valid
American shad life stage WUA/discharge relationships were not modeled since habitat criteria adequate for use in the Instream Flow Model were not developed from observations of lower Yuba River shad. Site-specific habitat criteria should be developed, and an IFIM study should be conducted to quantify the changes in shad life stage WUA over a broad range of flows. Key life stages are adult (migration and spawning), egg and larvae, and juvenile. Results of these subsequent investigations should be used to analyze flow needs and to develop recommendations to protect and enhance the American shad fishery of the Yuba River.

Until the above studies are completed, instream needs recommendations must be based on current understanding of American shad habitat needs.

Studies by Painter et al. (1979) indicate American shad spawning for the first time enter the mainstem Sacramento River and its tributaries in proportion to the outflow from that river or tributary during April, May, and June. Results of studies of the Yuba River American shad sport fishery angler catch rate (Meinz 1981) and analysis of Yuba River flows (Appendix I) indicate a greater shad population with increased flow over the years 1976-1978. Based upon the present understanding of American shad, flows of 1,000, 2,000, and 1,500 cfs during April, May, and June, respectively, should be adequate to attract adult fish, and maintain suitable spawning and American shad fishery conditions in the lower Yuba River. *What does this mean?*

X Publish it. much more on unpublished DFG to cough up.
Further, to promote shad spawning success and shad angler success, daily flow fluctuations during May and June should be minimized. Unpublished data from studies by DFG indicate that spawning intensity, measured by egg abundance, increases or decreases in the direction of the temperature change. This response to temperature change is believed to impact the catchability of shad as well. Since changes in streamflow affect water temperature, particularly downstream of Daguerre Point Dam, flow fluctuations should not exceed 200 and 150 cfs on a weekly basis during May and June, respectively.

was daily

690
A paragraph was removed here that said temps should not exceed daily average of 60 during April at Daguerre & Marysville & should be between 60-65 during May & June at Marysville. ⁻⁸⁰⁻

Conclusions

Chinook salmon and steelhead life stage WUA/streamflow indices for the lower Yuba River are similar. However, the indices suggest that chinook salmon require somewhat less streamflow than do comparable steelhead life stages. Chinook salmon spawning, fry, and juvenile habitats are maximized at 500 to 700, 100, and 150 to 200 cfs, respectively. Steelhead life stage habitats, on-the-other-hand, are maximized at 600 to 800, 100 to 200, and 200 to 350 cfs, respectively.

Run/glide habitat provides the most WUA for all salmon and steelhead life stages. It is also the most abundant macrohabitat type in the study area consisting of 37% of the lower Yuba River. The greatest concentration of this habitat is within the Garcia Gravel Pit and Daguerre Point Dam reaches where 94% of the river's habitat is found in these two reaches. The Garcia Gravel Pit Reach contains substantially more run/glide habitat (26,825 ft) than does the Daguerre Point Dam Reach (17,075 ft).

Evaluation of the chinook salmon and steelhead WUA/streamflow indices for the lower Yuba River, river sections, and species periodicities, provide insight into streamflows which benefit these anadromous species. The primary salmon and steelhead activities from mid-October through March are upstream migration, spawning, and egg incubation. The Garcia Gravel Pit and Daguerre Point Dam reaches provide nearly all of the spawning habitat in the lower Yuba River. A flow of about 700 cfs at the Marysville gage maximizes spawning habitat in the Garcia Gravel Pit Reach. Although spawning habitat maximizes at 400 to 500 cfs in the Daguerre Point Dam Reach, 700 cfs does not substantially reduce the amount of spawning habitat available. In addition, 700 cfs would facilitate upstream migration of adult fall-run chinook salmon and steelhead. Since spring-run chinook salmon enter the river from March through July, flows in the river during that period would affect their upstream movements.

During some years, irrigation demands may extend through October. Consequently, if 700 cfs is maintained downstream of Daguerre Point Dam, flows upstream in the Garcia Gravel Pit Reach could be as high as 1,785 cfs. Flows of this magnitude adversely affect available spawning habitat. However, since October is early in the chinook spawning period, and before steelhead begin to spawn, adverse effects on overall spawning success should be minimized.

Maintaining 700 cfs in the river throughout the spawning and incubation periods would prevent dewatering of redds and/or stranding of young chinook salmon and steelhead. In addition, maintaining at least 700 cfs during the juvenile chinook salmon

into the
mainstem
and steelhead outmigration period (April through June) would facilitate their downstream movement. Although 700 cfs would benefit salmon and steelhead spawning, incubation, and emigration life stages, maintaining 700 cfs in the river from approximately mid-October through June each year would reduce the amount of habitat available for chinook salmon and steelhead fry and juveniles.

Once young salmon and steelhead have emigrated (late June), maintaining approximately 300 cfs in the river would benefit juvenile steelhead. Flows in this range, however, could adversely affect spring-run chinook salmon upstream migration.

14
Virtually no information regarding American shad life stage streamflow needs were developed during this investigation. However, available information provides insight into shad instream needs in the lower Yuba River. Suitable conditions are needed during April to attract adult migrating shad. Evaluation of American shad occurrence and distribution, and angler effort and catch information suggest that a streamflow of 1,000 cfs at the Marysville gage during April; 2,000 cfs during May; and 1,500 cfs during June would provide suitable attraction, migration, spawning, and shad recreational fishery flows. No information is available pertaining to streamflows which may benefit American shad rearing and emigration needs.

Integrating chinook salmon, steelhead, and American shad streamflow/habitat relationships on the lower Yuba River is necessary to develop a flow regime which balances species life stage needs. Habitat needs vary with time of year and life stage. Chinook salmon and steelhead primary activities from mid-October through March are adult migration, spawning, egg incubation, and fry rearing. March through mid-October primary activities are adult migration, spawning, egg incubation, and fry rearing during April, May, and June.

Seven-hundred cfs in the lower Yuba River from mid-October through March would provide good conditions for salmon and steelhead adult, migration, and spawning. Maintaining this flow would ensure that redds would not be dewatered, and that young salmonids would not be stranded. Flows of this magnitude would reduce salmonid fry and juvenile habitat. However, this reduction in habitat is not considered significant. On-the-other-hand, 700 cfs flow would benefit early outmigrant juvenile spring-run chinook salmon.

Revised - Since most salmonid smolt emigration has already occurred

One-thousand, 2,000, and 1,500 cfs at the Marysville gage in April, May, and June, respectively, would provide suitable conditions for continued spring-run salmon smolt emigration and suitable conditions for fall-run salmon and steelhead smolt emigration. Further, the flows would prevent salmonid redd dewatering and young fish stranding. They would also provide acceptable adult spring-run chinook salmon attraction and

migration flows as well as American shad attraction, migration, and spawning flows. In addition, these flows would provide suitable shad angling conditions.

Flows ranging from 1,000 to 2,000 cfs during April, May, and June would reduce the amount of fry and juvenile salmonid physical habitat which would be available at lower flows. Flows of this magnitude, however, are necessary to ensure meeting other species life stage needs. Further, in view of the lower Yuba River's degraded condition, habitat modification programs could redevelop fry and juvenile habitats at these flows.

no quantifiable bases. T 25122

the hab
is also
there,

Two-hundred-fifty to 450 cfs at the Marysville gage during July through mid-October would provide good young steelhead and shad rearing conditions. Flows upstream of Daguerre Point Dam could range up to 1,535 cfs during this period, but the impacts on young steelhead and shad should not be significant. Further, these impacts could be ameliorated by redeveloping juvenile steelhead physical habitat upstream of Daguerre Point Dam.

WATER QUALITY CONDITIONS

Man's activities have historically adversely affected the quality of water in the lower Yuba River. Investigations were conducted to: 1) identify and locate known point source discharges within and upstream of the study area, 2) evaluate water quality characteristics, and 3) determine the potential solutions to any identified water quality problems.

Existing water quality data were collected and analyzed for the Yuba River from New Bullards Bar Dam downstream to the confluence with the Feather River. Information from the following sources was used to describe water quality dating from 1950: published and in-house agency reports; STORET data bank; WATSTORE data bank; and selected agency files and personal communications of the DFG, California Regional Water Quality Control Board (RWQCB), California Water Resources Control Board (CWRCB), U.S. Environmental Protection Agency (USEPA), U.S. Fish and Wildlife Service (USFWS), and U.S. Army Corps of Engineers (USACOE). This water quality data is contained in Appendix IV. Water quality sampling sites are found in Figure 2.

With the exceptions of the urbanized area near the Yuba River at Marysville and the Yuba Goldfields, land use along both banks of the river within the study area is primarily agricultural. No active hydraulic mining in the Yuba River within the Yuba Goldfields is permitted.

Point Discharges

No point discharges (sewer treatment plant outfalls, industrial discharges, agricultural return flows) that require National Pollution Discharge Elimination Systems (NPDES) permits empty directly into the lower Yuba River. However, NPDES permits have been issued for two point discharges located on Deer Creek. Dischargers of treated domestic wastewater into Deer Creek, a tributary entering the lower Yuba River just downstream of Englebright Dam, include the City of Nevada City and the Nevada County Sanitation District No. 1 (Lake Wildwood) (Figures 1 and 2). A third, provisional NPDES permit was issued in 1984 for discharge of domestic wastewater from a proposed tertiary treatment facility into Sanford Creek, another tributary near Smartville. This waste treatment facility, part of a 199-unit development supervised by the Hammonton Golden Village Homeowner's Association, has yet to discharge effluent into Sanford Creek.

Monthly monitoring reports submitted to the RWQCB by Nevada City and Nevada County Sanitation District include measurements of effluent volume, biochemical oxygen demand, suspended matter, settleable matter, specific conductivity, pH, total coliforms, and residual chlorine at the point discharge site. Review of these

and other records indicate that no adverse effects on water quality from these dischargers are evident in the lower Yuba River.

The management of Lake Wildwood by the Lake Wildwood Homeowners Association does create water quality problems in the Yuba River. The lake is drawn down each year for maintenance and removal of accumulated sediments. This activity often results in discharge of sediments to and increased turbidity in Deer Creek and the lower Yuba River. The fishery in Deer Creek below Lake Wildwood has been adversely impacted due to the discharge of effluent and/or sediment discharge, reduced flows and increased water temperatures (John Hiscox, DFG, per. comm., 1989). This siltation may adversely affect aquatic organisms and reduce available spawning habitat due to sediment deposition. Presently, facilities are being developed to prevent the sediments from reaching Deer Creek and the lower Yuba River.

Non-Point Discharges

The existing water quality character of the lower Yuba River is determined by non-point sources, including runoff from adjacent lands and groundwater accretion. With the exception of streams tributary to the lower Yuba River, all potential sources of water pollution that do not originate from a point source are considered to be non-point discharges.

General Water Quality Characteristics of the Lower Yuba River

The water quality parameters included in Table 19 are commonly used to describe the general water quality of natural waters. Water temperature is discussed in a separate section.

Table 19. List of parameters commonly used to describe general water quality conditions.

Dissolved Oxygen	Magnesium	Bicarbonate
pH	Sodium	Nitrate
Total Dissolved Solids	Potassium	Nitrite
Conductivity	Chloride	Total Alkalinity
Turbidity	Sulfate	Total Phosphorus
Calcium	Carbonate	Total Hardness
Chemical Oxygen Demand	Ammonia	Water Temperature
Biochemical Oxygen Demand		

The data evaluated during this study indicate that the general water quality of the lower Yuba River is quite good. Dissolved oxygen concentrations are high and near ideal for supporting

salmonids. Total dissolved solids, pH, hardness, alkalinity, and turbidity are well within acceptable and even preferred ranges for salmonids and other key freshwater biota. Despite extensive surrounding agricultural land use, nutrients (i.e., phosphorus, nitrogen) are generally below concentrations considered promotive of algal growth and other common symptoms of enrichment. Ammonia has consistently been well below levels considered harmful to salmonids.

Inorganic Elements

Arsenic, nickel, selenium, and iron have been detected in the lower Yuba River, but in quantities well below the USEPA (1986) acute or chronic freshwater criteria. No criteria are specified by the USEPA (1986) for aluminum, barium, boron, and manganese. However, concentrations of these elements have been at or below average for natural freshwaters and well below toxic levels. Concentrations that exceed the USEPA (1986) criteria or which are otherwise considered unsafe or harmful to freshwater biota have been measured for cadmium, copper, lead, mercury, and zinc. However, such concentrations occurred infrequently and were probably in a less toxic complex form or particulate form. In addition, the consistent detection of mercury in sediment and tissue samples verifies the continuing presence of historical gold processing by-products.

Other Substances or Compounds

This category refers to a variety of inorganic and organic constituents which are typically not found in natural waters and, if found, indicate contamination from man-made chemicals. If present, these substances typically are found in small amounts, but in many cases are highly toxic.

Samples for substances or compounds, such as cyanide, chloroform, pesticides, petroleum hydrocarbons, and polychlorinated biphenyls (PCBs), have been taken in the lower Yuba River. Cyanide, chloroform, and petroleum hydrocarbons have not been detected. With the exception of DDT, DDE, and DDD, and PCBs, no pesticides or other chlorinated organics were found in detectable quantities in water, fish tissue, or sediment samples. The detection of DDT, DDE, DDD, and PCBs in fish tissue samples is consistent with the fact that extremely high bioaccumulation can occur even with low or undetectable levels of DDT or PCBs in water or sediments. The presence of DDT (and some of its metabolites) and PCBs in fish tissues has also been detected in other California drainages with a history of appreciable agricultural runoff (LaCaro et al. 1981), and an on-going monitoring program has been implemented (CWRCB 1987). DDT has been banned since 1972, and PCBs have been highly restricted since 1979. As a result, levels of DDT and PCBs in the environment have steadily decreased. However, both are expected to remain as detectable fish tissue contaminants for many years because of their persistence and movement in the environment (LaCaro et al. 1981).

Conclusions

No point discharges (sewer treatment plant outfalls, industrial discharges, agricultural return flows, etc.) that require NPDES permits empty directly into the lower Yuba River. Discharges of treated domestic wastewater into Sanford Creek and Deer Creek, tributaries of the lower Yuba River, do not appear to have adverse effects on water quality of the lower Yuba River, but, the Deer Creek fishery has been adversely impacted. Maintenance at Lake Wildwood has created sediment discharges in the past. However, facilities are being developed to prevent the sediments from reaching Deer Creek and the lower Yuba River.

Analysis of dissolved oxygen concentrations, total dissolved solids, pH, hardness, alkalinity, and turbidity indicate that the general water quality of the lower Yuba River is quite good and well within acceptable ranges for salmonids and other key freshwater biota. Nutrients, such as phosphorus and nitrogen, are generally below concentrations considered promotive of algal growth. Ammonia has consistently been well below levels considered harmful to salmonids.

Concentrations of minor or trace elements that exceed the USEPA (1986) criteria or which are otherwise considered unsafe or harmful to freshwater biota have been measured for cadmium, copper, lead, mercury and zinc. Such concentrations occur infrequently.

Detectable concentrations of DDT, DDE, and DDD, and PCBs have been found in water, fish tissue, or sediment samples but the concentrations have not been considered unsafe or harmful to freshwater biota.

Water quality of the lower Yuba River is good and it does not appear problems will develop in the near future, however, the following water quality criteria are recommended to be achieved in receiving waters below Englebright Dam and Daquerre Point Dam as follows:

- 1) Dissolved oxygen not less than 7.0 ppm.
- 2) The pH not to exceed the range of 6.5 to 8.5.
- 3) No discharge of heavy metal or other constituents which cause chronic or acute toxicity to any life stage of the aquatic resources.
- 4) No discharge of turbid water or water containing settleable solids in excess of RWQCB Basin Plan Standards.

*covered under
basin plan?*

CHANNEL STABILITY ANALYSIS
AND
SPAWNING GRAVEL RESOURCES ASSESSMENT

The IFIM used to evaluate fish habitat and flow relationships in the fisheries investigations assumes stable and constant channel morphology. The usefulness and validity of the IFIM model depends upon the ability to predict the future character and mechanics of the sediment transport system. Dams alter the sediment supply and discharge resulting in long-term effects on channel morphology and substrate that may change the amount and suitability of spawning substrates.

Historical Channel Stability

An historical channel stability analysis was conducted to evaluate the applicability of assumptions about channel morphology and geomorphic processes related to the validity of IFIM in the lower Yuba River. This involved extensive analysis of historical maps and channel cross sections of the river principally from Gilbert (1917) and Adler (1980) (Figure 2), USGS gaging records, and aerial photographs.

The lower Yuba River has undergone profound changes in channel course, pattern, and bed elevation since the mid-19th century as a result of a massive influx of sediment derived from hydraulic mining in its basin. Hydraulic mining abruptly ceased in 1884, but the lower Yuba River continued to aggrade for about 20 years (Figure 30). After the turn-of-the-century, the braided, unstable channel gave way to a stable, single-thread channel deeply incised into the recently deposited debris plain. The incision was the result of natural recovery from a major aggradational event, and to a lesser extent, the influence of engineering works such as debris dams and training levees. Although definitive evidence is lacking, it appears that the recovery from the influx of hydraulic mining debris (incision and accompanying stabilization) was largely complete by about 1950.

Lateral channel migration was observed as late as 1973 through 1986 and can be viewed as normal in quasi-equilibrium. The geometry of the shifted channel is likely to remain unchanged, so the distribution of depths and velocities for a given discharge are probably stable.

Gravel Resources Assessment

A largely qualitative assessment of gravel resources was performed based upon field reconnaissance, sampling of gravel deposits, and knowledge of recent geomorphic history of the channel.

Spawning gravels are scarce in the Narrows Reach because of the lack of upstream recruitment due to Englebright Dam, and because

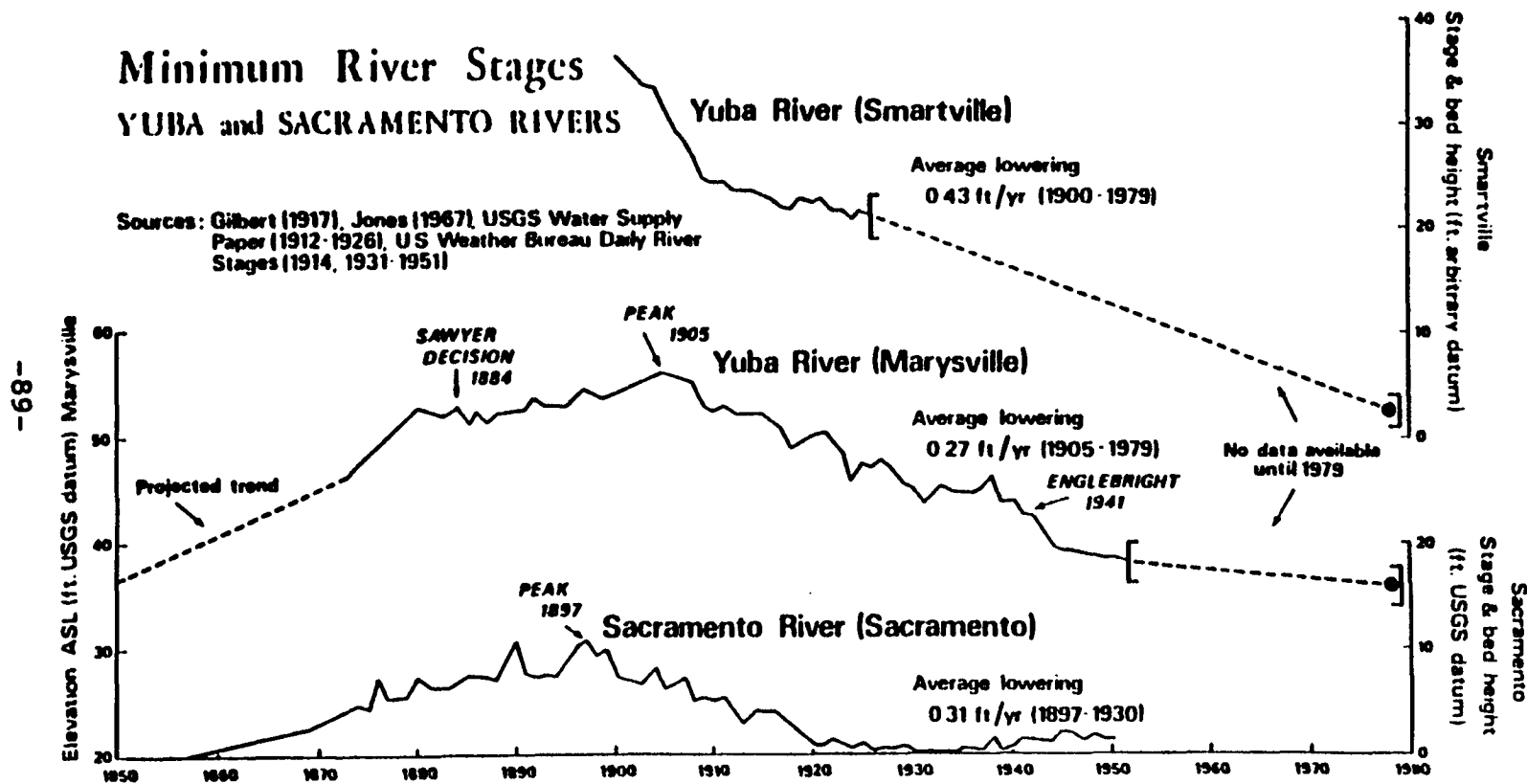


Figure 30. Passage of peak hydraulic mining debris as recorded by minimum river stages, Yuba and Sacramento rivers, California (from Adler 1980).

the high-energy canyon environment discourages deposition. Gravel is abundant and of generally good quality in the Garcia Gravel Pit and Daguerre Point Dam reaches. In the lower part of the Simpson Lane Reach, the bed becomes dominated by finer-grained deposits and gravels become less plentiful. Gravels that occur in this reach contain higher fine sediment fractions, and thus are less suitable for salmon spawning. Even in the Daguerre Point Dam Reach, numerous gravels were observed to have high levels of interstitial fine sediments. However, gravels in the preferred spawning sites were loose, and thus potentially usable by spawning fish. This is probably due to the flushing and mixing of the bed material by periodic high flows, such as during 1986.

NEW

remains gravel?
The lower Yuba River downstream of the Narrows possesses an abundance of suitably-sized chinook salmon spawning gravel, remaining from the massive deposits of hydraulic mining debris dating from the turn-of-the-century. Because of the tremendous volumes of gravel remaining in the river, it is unlikely that spawning gravel will be in short supply in the foreseeable future. Armoring of the channel bed (rendering suitable spawning gravels inaccessible to spawners by development of an immobile layer of cobble over the usable gravel beneath) is possible, but has not developed to-date.

remains gravel?
However, the DFG believes the habitat for fry and juvenile life stages of salmon and steelhead are currently less than optimum. This is believed due to channel narrowing and incision that have acted to reduce available habitat for these life stages.

Conclusions

The available evidence indicates that the lower Yuba River is probably now in equilibrium with prevailing water and sediment discharge and that results of an IFIM study can be extrapolated into the future under existing basin conditions.

No evidence of gravel limited.
Overall, the spawning gravel resources in the lower Yuba River can be considered excellent based on the abundance of suitable gravels in the Garcia Gravel Pit and Daguerre Point Dam reaches. However, no new recruitment of gravel can occur in the Narrows Reach due to the presence of Englebright Dam. Gravel extraction within this area should be carefully evaluated and monitored. Gravel of suitable quality and quantity should be placed at locations between the Narrows and Englebright Dam to improve the spawning conditions for adult spring-run chinook salmon. Future licenses and permits for projects on the Yuba River should be conditioned to provide for gravel replenishment, as necessary.

Gravel extraction within the Yuba River flood plain should be restricted to skimming type operations that only remove materials not suitable as substrate for spawning chinook salmon and steelhead. Excavations below the thalweg should only be allowed

behind levees capable of protecting the work area from a 100-year flood event. No activities should be allowed which could result in changes in channel location.

Spawning habitat for salmonids shall be maintained through conditions that prevent sedimentation and gravel cementation.

Habitat improvement projects should be implemented and should include construction of shallow "rearing" areas and "braided" channels designed to optimize habitat requirements for fry and juveniles.

Revised
Stocking of additional steelhead fry should be considered to increase GH populations.

BARRIERS TO ANADROMOUS FISH MIGRATION

For nearly a century, the lower Yuba River has been plagued by a number of barriers to the upstream migration of anadromous fishes. Hydraulic mining activity during the latter half of the 19th century generated over 6 million cubic yards of gravel and debris, and much of it was washed into the Yuba River. To prevent downstream movement of this debris, a debris dam was constructed in 1904-1905. This dam completely blocked the river to upstream fish passage. The dam washed out 2 years later. In 1906, Daguerre Point Dam was constructed 4.5 mi downstream of the original debris dam as a more permanent structure (Figure 2). Fish ladders were provided in Daguerre Point Dam, but were ineffective. By 1950, the passage problems for chinook salmon and steelhead trout improved with the installation of new and more efficient ladders at Daguerre Point Dam. Currently, upstream passage through Daguerre Point Dam is considered adequate for chinook salmon based upon annual spawning stock surveys conducted by the DFG. However, few American shad and no striped bass use this facility (Wooster and Wickwire 1970). Upstream of Daguerre Point Dam, construction of the Old Bullards Bar Dam in 1921 and Englebright Dam in 1941 completely blocked upstream movement of fish.

More recently, upstream movement over shallow riffles during minimum flow conditions were of concern. Minimum flow for fish are specified by an agreement executed September 2, 1965 between the DFG and the YCWA. The agreement specifies minimum flows at the crest of Daguerre Point Dam and through its fishways under average water year conditions: 70 cfs is the minimum to be released from July 1 through September 30; 400 cfs October 1 through December 31; and 245 cfs between January 1 and June 30. Minimum flows are subject to dry year conditions, where reductions up to 30% are based upon water year streamflow forecasts by the California Department of Water Resources (DWR). The absolute minimum fishery release is 70 cfs. A copy of the 1965 agreement is contained in Appendix V.

Aerial surveys of the lower Yuba River were conducted on October 14 and November 12, 1986 to assess current conditions for upstream migration and distribution of spawning fall-run chinook salmon. Distribution of spawning was further evaluated using aerial photographs and from the ground during microhabitat surveys of spawning salmon.

Naturally occurring critical riffles were identified during habitat mapping and represented by IFIM transects located at the Simpson Lane and Daguerre Point Dam IFIM transect sites (Figure 2). Depth measurements were collected along two transects at each of the two lower sites on July 17, 1987, to assess minimum fishery flow conditions (70 cfs). PHABSIM was used to simulate water

was "under"

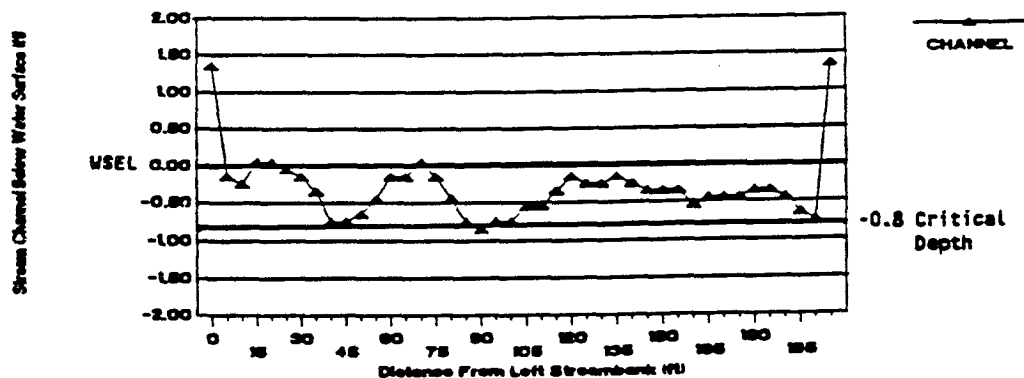
surface elevations related to discharge levels beyond those flows measured. Additionally, a critical riffle beginning directly below Transect 1 at the Simpson Lane site was surveyed for its longitudinal profile. Measurements of maximum water depth were taken along the thalweg beginning at the crest of the riffle and extending downstream to the head of the next pool. Measured discharge levels were 35 cfs at Daguerre Point Dam and 84 cfs near Simpson Lane.

The recommended minimum clearance depth for upstream migration of adult chinook salmon varies in the literature. Thompson (1972) suggests a minimum depth of 0.8 ft. Further, the minimum depth must cover continuously at least 10% of the stream's cross-sectional profile. Lastly, 25% of the cross-section must also meet the criteria, though not within contiguous widths. Evans and Johnston (1980) recommend a passage minimum depth of 1.0 ft. A depth equaling two-thirds of the fish's body depth is mentioned by Bovee (1982).

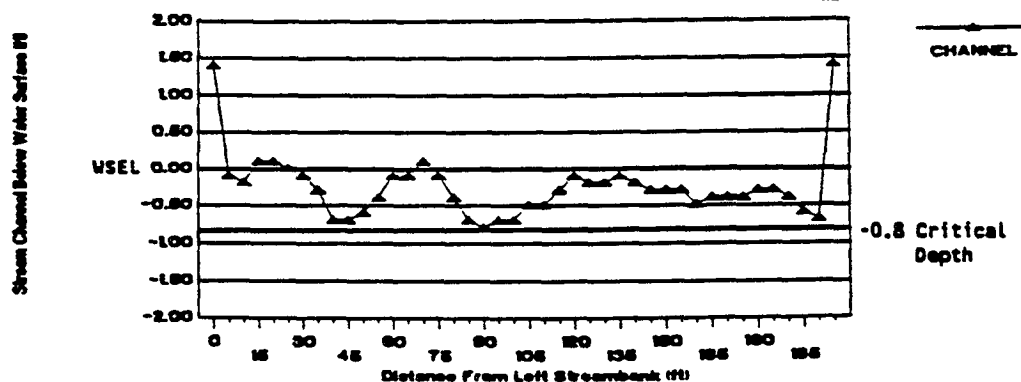
NEW
Results of aerial and ground level surveys of the lower Yuba River during October through December 1987, when chinook salmon upstream migration and spawning were at their peak, revealed that there were no barriers to upstream migration at prevailing flows. This was substantiated by the presence of spawning salmon throughout the lower Yuba River to Rose Bar and confirmed that the Daguerre Point Dam fish ladders were operational under the observed flow conditions. Mean monthly flows at Marysville during October through December were 461, 497, and 684 cfs, respectively (USGS 1988).

July 1-Sept 30
only spring
run & a
few SH
migrating.
*
Comparison of fish passage criteria to conditions available in the lower Yuba River at and below Daguerre Point Dam indicate 70 cfs is not sufficient to meet depths approximating Thompson's (1972) criteria at the riffles posing greatest passage limitations in the Simpson Lane and Daguerre Point Dam reaches. Results of the PHABSIM analysis at the Daguerre Point Dam and Simpson Lane transect sites are contained in Appendix VI. Of the critical riffles evaluated, the riffle posing the greatest potential to prevent fish passage is the Simpson Lane IFIM Transect 1. Even at a flow of 100 cfs, the Simpson Lane IFIM Transect 1 would not meet fish passage criteria (Figure 31). It is doubtful that a flow of 100 cfs would be sufficient to meet the criteria for the Simpson Lane Critical Riffle Thalweg site below Transect 1 (Figure 32). Therefore, streamflows in excess of 100 cfs are necessary to provide minimum upstream passage for adult chinook salmon at all locations along the lower Yuba River downstream of Daguerre Point Dam. Extrapolation of the Simpson Lane IFIM Transect 1 data indicates that a minimum of approximately 175 cfs are required to meet Thompson's (1972) criteria.
15
NEW

SIMPSON LANE TRANSECT-1 AT 100 CFS



SIMPSON LANE TRANSECT-1 AT 84 CFS



SIMPSON LANE TRANSECT-1 AT 50 CFS

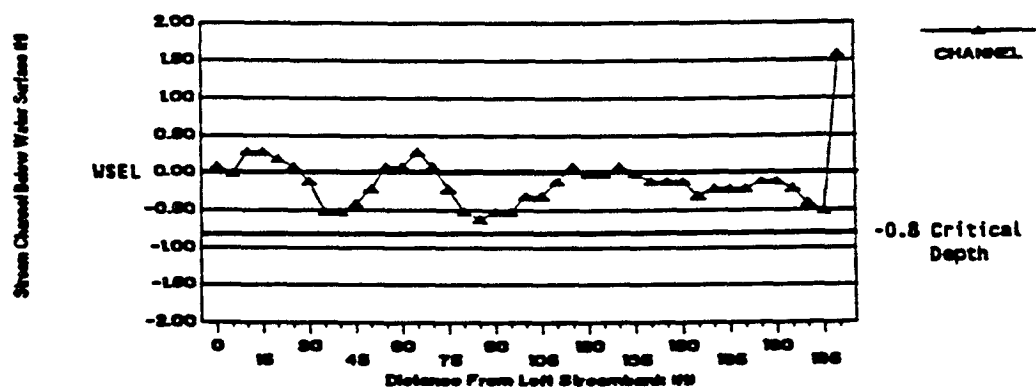


Figure 31. Height of stream channel to water surface elevation (ft) at Simpson Lane IFIM Transect-1 site, lower Yuba River, California. Depths measured at 84 cfs, depths estimated using PHABSIM for flows of 50 and 100 cfs.

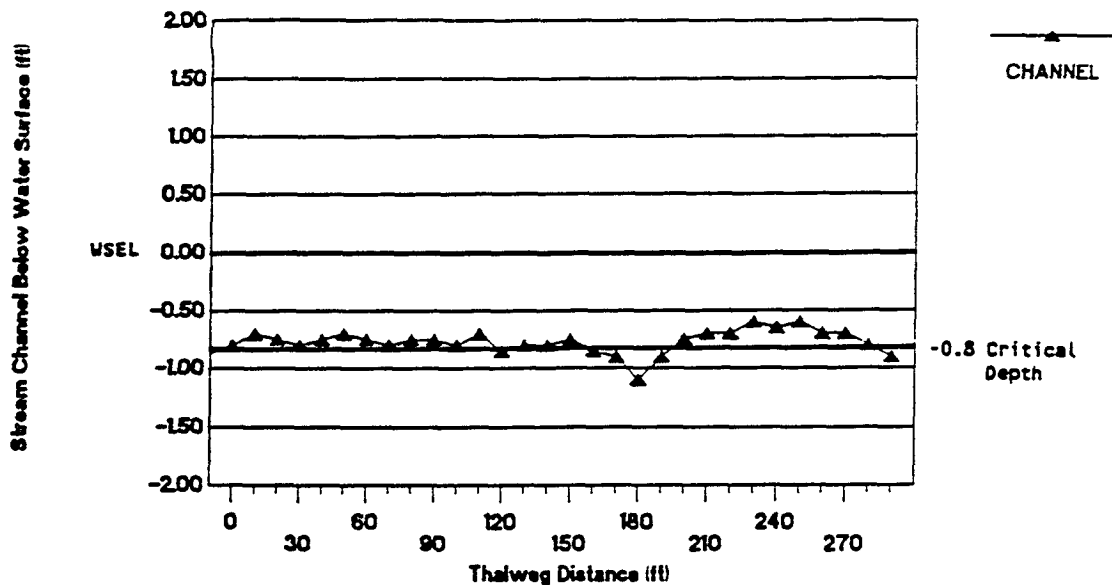


Figure 32. Height of stream channel to water surface elevation (ft) at Simpson Lane Critical Riffle Thalweg site at 84 cfs, lower Yuba River, California.

Conclusions

Flows of 175 cfs are needed to provide minimum upstream passage for adult chinook salmon. This was determined using the depth criteria of 0.8 feet covering continuously a minimum of 10% as well as 25% of the non-contiguous area of the stream cross-section as the minimum clearance depth for adult chinook salmon upstream migration.

Fish passage over Daguerre Point Dam appears adequate for chinook salmon and steelhead, however, few American shad and no striped bass are found upstream.

Is this a YCWA issue?

EFFECTS OF FLOW DIVERSIONS
ON
JUVENILE ANADROMOUS SALMONIDS

Existing and proposed water rights and diversions were identified and characterized for the lower Yuba River from Englebright Dam downstream to the confluence with the Feather River.

The adequacy of fish screening facilities at existing diversions was also assessed.

Location and Characteristics of Diversions

There are numerous riparian and appropriative water rights existing along the lower Yuba River (Figure 33). The primary consumptive use is offstream irrigation, which accounts for more than 90% of offstream water users. The Yuba County Water Agency (YCWA) is the most significant holder of water rights with permits or licenses for 2,080,000 AF per year. The YCWA supplies water for diversion primarily to the Hallwood Irrigation Company (78,000 AF), Cordua Irrigation District (72,000 AF), Ramirez Water District (13,900 AF), Browns Valley Irrigation District (25,687 AF), Brophy Water District (35,330 AF), and South Yuba Water District (22,100 AF) (Table 20). An additional 18,204 AF exists in miscellaneous riparian and active sales contracts. The Hallwood Irrigation Company, Cordua Irrigation District, and Ramirez Water District collectively divert water through the Hallwood-Cordua Canal. The Brophy and South Yuba water districts divert through the Brophy-South Yuba Canal. These water districts have either their own water rights and/or purchase water through contract from the YCWA. Also, the YCWA is presently actively seeking sale of Yuba River water to other downstream users and the California Department of Water Resources (DWR). Diversions from the lower Yuba River generally occur during the period March through October.

The Hallwood-Cordua Canal gravity flow diversion is located on the north bank at Daguerre Point Dam and diverts a maximum of 625 cfs. The Browns Valley Irrigation District diverts a maximum of 80.2 cfs using a pump for diversion and is located on the north bank about 4,750 ft upstream of Daguerre Point Dam. The Brophy-South Yuba Canal, a gravity flow diversion that diverts a maximum of 380 cfs, is located on the south bank and just upstream of Daguerre Point Dam.

Entrainment and Impingement at Diversions

The three major diversion facilities, Browns Valley Irrigation, Hallwood-Cordua, and South Yuba and Brophy water districts, have intake screening devices to prevent losses of juvenile salmonids and other fishes. The Browns Valley Irrigation District diversion is partially screened by a gabion which was constructed in 1983. The gabion initially stretched across the mouth of the slough

Figure 33. Location of diversions, lower Yuba River, California.

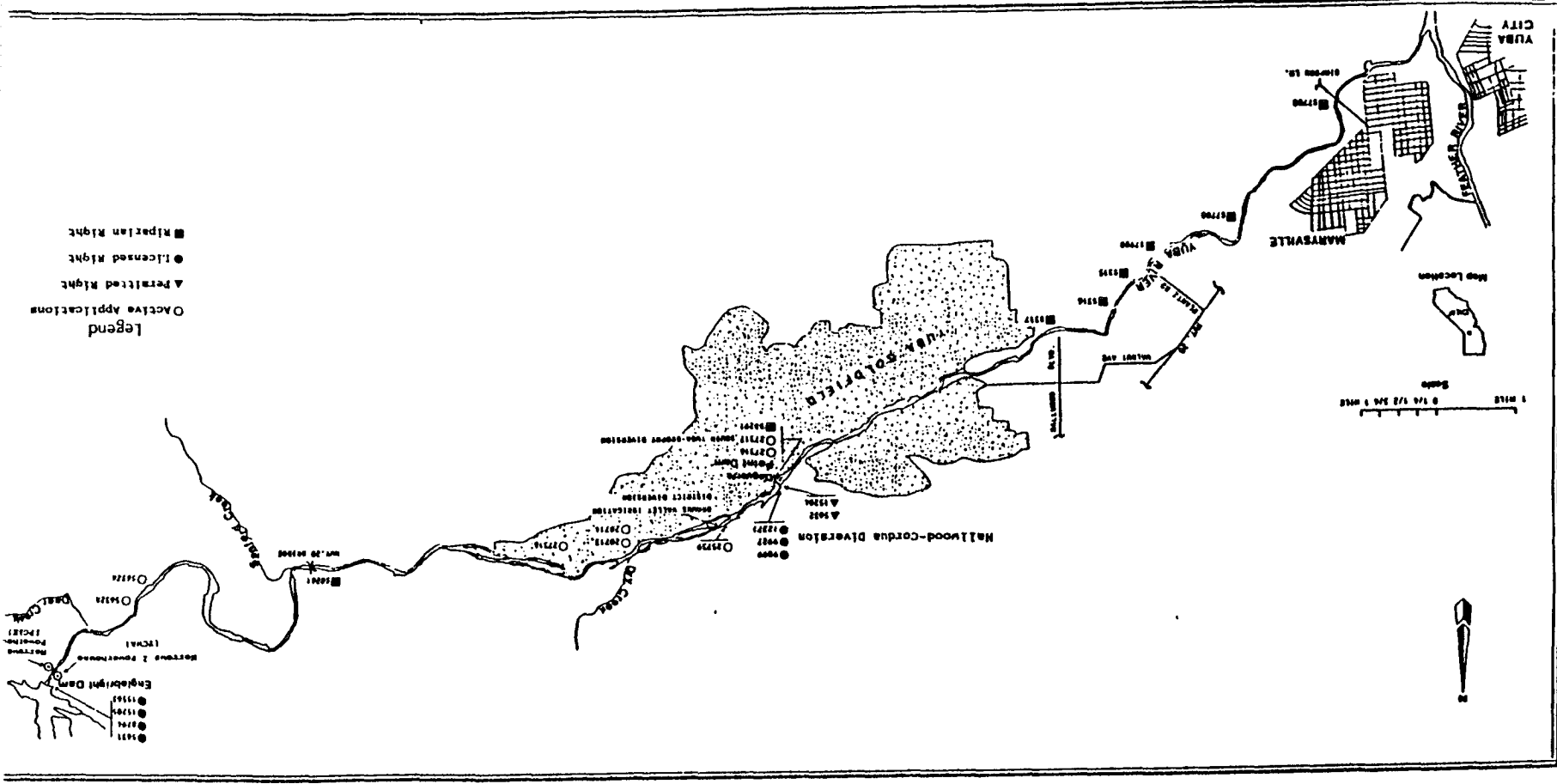


Table 20. Summary of diversion rates (AF) by month for the major water districts supplied by the Yuba County Water Agency, lower Yuba River, California (data supplied by the YCWA).

Month	Hallwood Irrigation Company	Cordua Irrigation District		Ramirez Water District	Browns Valley Irrigation District		Brophy Water District	South Yuba Water District
	WR*	WR	PW+	WR	WR	PW	PW	PW
1987 Mar	0	0	0	0	0	0	520	300
1987 Apr	10,000	4,500	900	2,010	2,269	1,667	4,795	3,000
1987 May	14,500	10,600	2,120	3,270	2,345	1,666	6,460	4,000
1987 Jun	14,100	10,400	2,080	2,745	2,269	1,667	6,670	4,200
1987 Jul	13,600	11,100	2,620	1,920	2,345	2,500	6,985	4,400
1987 Aug	12,900	11,000	2,600	1,755	2,345	2,000	5,525	3,400
1987 Sep	8,000	5,900	1,180	1,500	2,269	0	3,750	2,400
1987 Oct	4,900	6,500	500	700	2,345	0	625	400
Total	78,000	60,000	12,000	13,900	16,187	9,500	35,330	22,100
Max cfs	275		275	75	38.2	42	230	150

* (WR) Basic water right of respective water district.

+ (PW) Purchase water through contract with YCWA.

where the pump is located. However, a breach was cut through the gabion near the upstream bank to enhance diversion flow after it became clogged. This breach has reduced the gabion's effectiveness to screen out fry and juvenile fish. The DFG monitored this diversion to estimate the chinook salmon smolt loss in June 1987 (DFG 1987b). Entrainment losses of smolts were calculated for diversion flows ranging from 10 to 75 cfs with 60-day losses estimated to range from 87 to 1,200 fish, respectively. At the maximum legal diversion rate of 42 cfs, total loss over a 60-day period was estimated to be 525 fish. These losses appear small, however the overall cumulative effect of losses at all diversion sites make these losses significant.

The Hallwood-Cordua gravity flow diversion utilizes a V-shaped punched plate screen that is operated and maintained by DFG. At the apex of the "V" a bypass system diverts fish to a collection tank. The collected fish are returned to the river either through a pipeline or by truck. This screen is efficient in preventing the entrainment and impingement of juvenile salmonids (Hall 1979). However, losses due to predation, principally by Sacramento squawfish, occur near the screen face and upstream in the intake channel. Losses ranged from 19.0% to 50.2% for test groups examined during 1977 and 1978.

The South Yuba-Brophy gravity diversion is screened by a rock levee which was completed in 1985. The levee separates the diversion pool from a diversion and bypass channel flowing parallel to the levee. Its function is to prevent fish from entering the diversion pool. The approval of this screening device by DFG was contingent upon a 3-year study to ascertain whether the levee would be 95% effective in preventing entrainment to the diversion pool. The DFG surveyed the diversion pool inside of the rock levee in March 1987. It was concluded that the levee is permeable to small fish including chinook salmon, even when the diversion is not operational, and that it would pass significant numbers of salmon in proportion to the amount of water diverted (DFG 1987a). Further studies of fish losses through the rock levee were conducted in May 1988 using marked juvenile chinook salmon (DFG 1988). Flows passing through the rock levee into the diversion pool were estimated to be 80 cfs, 21% of the maximum flow capacity of 380 cfs. No chinook salmon (marked or unmarked) were found in the diversion pool. Although, no salmon were diverted, losses did occur. Approximately 50% of the fish lost were attributed to predation by Sacramento squawfish in the diversion and bypass canal on the upstream side of the rock levee.

Natural Predation on Juvenile Chinook Salmon

The extent of predation on migrating juvenile salmonids in the lower Yuba River is unknown. However, Daguerre Point Dam and the local diversion structures do provide conditions conducive to excessive predation, and may contribute to significant salmonid losses. Significant predation of juvenile salmonids has been documented in the Sacramento River at the Red Bluff Diversion Dam (Hall 1977) and in the Yuba River at the Hallwood-Cordua fish screen (Hall 1979). The Brophy-South Yuba Diversion, located across the river opposite the Hallwood-Cordua Diversion, is another location where the impact of predation may be significant. Losses may also occur immediately below Daguerre Point Dam where emigrating salmonids may become disoriented by turbulent flow conditions associated with passage over the face of the dam.

The stomach contents of Sacramento squawfish greater than 7.75 in were examined for the presence or absence of juvenile chinook salmon to evaluate squawfish predation on chinook salmon in the lower Yuba River. Squawfish were captured by electrofishing at nine sites located throughout the four reaches during February and May of 1987. Other species known to prey on juvenile salmonids, including striped bass, steelhead trout, largemouth bass, smallmouth bass were not sampled in sufficient numbers for analysis.

Sixteen Sacramento squawfish stomachs for content analysis were collected during February and May 1987. The Squawfish examined ranged from 15.9 to 26.6 in (FL). Fourteen stomachs were found

to be empty. A single juvenile chinook salmon was present in each of the two remaining stomachs. One of the two stomachs also contained a Pacific lamprey ammocete. The absence of food items may be due to the tendency of large squawfish to regurgitate their stomach contents when captured by most methods and as a result of their relatively high digestion rates (Brown and Moyle 1981). As a result, it is difficult to conclusively determine the extent and impact of squawfish predation of juvenile salmonids based solely on stomach content analyses.

Conclusions

The three most significant diversions along the lower Yuba River are located at or near Daguerre Point Dam, and diversions generally occur from late March through October. The Hallwood Irrigation Company, Cordua Irrigation District, Ramirez Water District, Brophy and South Yuba water districts, and Browns Valley Irrigation District combined divert up to a maximum of 1,085 cfs.

Juvenile chinook salmon are lost at all three diversion intake structures due to impingement, entrainment, and/or predation. Individual losses at these diversions may not be significant. However, the cumulative impact of these losses is significant.

Evaluation of predation on juvenile chinook salmon by Sacramento squawfish found at sites away from diversion structures was inconclusive. However, previous studies have documented significant predation on young chinook salmon by Sacramento squawfish at the Hallwood-Cordua fish screen on the Yuba River and at the Red Bluff Diversion Dam on the Sacramento River.

In accordance with Fish and Game Code Section 6100, all ^{operative word} new diversions of water from the Yuba River should be screened according to criteria established by the Department. Existing water diversions from the Yuba River (Brophy-South Yuba, Browns Valley Irrigation District, Hallwood-Cordua Irrigation District) are resulting in significant losses of fry and juvenile salmon and steelhead. Existing gravel and weir type fish screens have proven unreliable and ineffective and should be replaced and screened according to ~~current DFG criteria~~ with "state of the art" perforated plate or wedge wire type screens located "on river".

RIPARIAN VEGETATION

Most of the original plant communities along the lower Yuba River have been significantly altered from pristine conditions (USACOE 1977). Although little is written specifically about the pristine riparian forests of the lower Yuba River, it is believed that the banks of the lower Yuba River and its adjacent natural levees once were covered by riparian forest of considerable width. It has been suggested that most riverine flood plains in California's Central Valley supported riparian vegetation to the 100-year flood plain. It is likely that the Yuba River was no exception.

Riparian vegetation is important to the maintenance of the anadromous salmonid fishery by providing: (1) stabilization of river banks and reduction of sediment load in the channel, (2) provision of shade to the stream channel thereby reducing water temperature and providing overhead cover for fish, (3) enhancement of stream nutrients due to decay of plant debris, and (4) provision of streamside habitat for aquatic and terrestrial insects that are preyed upon by fish.

Existing Plant Communities

Plant communities of the study area were mapped from color aerial photographs taken in October 1986 prior to significant leaf fall. From these photographs it was evident that most of the river is not shaded by the existing riparian plant community.

Three plant communities, one topographic feature, and one generally designated unit of urban influence were mapped. The plant communities were determined to be blue oak/digger pine woodland, riparian forest, and grassland/agriculture. The topographic feature mapped was hydraulic mine tailings. Urban influences mapped were gravel mines, houses, and off-road vehicular use of the river bank.

Riparian vegetation accounted for 56% of the total lineal shoreline coverage downstream of Englebright Dam (Table 21). Blue oak/digger pine woodland accounted for 23%, hydraulic mine tailings 11%, and all other community types combined 10%.

The existing riparian vegetation community has little influence or impact on the aquatic resources of the lower Yuba River. For example, most of the stream channel does not receive shade from any vegetation. In terms of fishery management, there is a need to restore and/or enhance the existing riparian community. Presently, riparian vegetation in the lower flood channel downstream of the Yuba Goldfields is regularly removed by DWR as part of an ongoing flood flow maintenance program.

Comparison of Existing and Historical Vegetative Cover

The intent of this investigation was to compare the results of this riparian investigation to those published by the U.S. Army Corps of Engineers (USACOE 1977) to quantitatively assess the magnitude of changes that may have occurred in the past decade. However, only a qualitative comparison is attempted due to possible differences in criteria used to distinguish community types and the resolution of information available from the USACOE vegetation and land use map.

The extent of community types in the Narrows Reach during the 1970s is essentially identical to that present today (Table 21 and 22). In the Garcia Gravel Pit Reach, there may have been significant changes in streamside conditions since the early 1970s. Oak/pine woodland and chaparral comprised 11.2% of the streamside in the 1970s, but now comprise 35%. In the 1970s, riparian vegetation was present along about 9% of the reach, whereas it is currently present along 44% of the reach. The dominant streamside feature in the 1970s was hydraulic mine tailings (70%), that currently comprises only 16% of the reach.

Table 21. Estimated extent of linear features along the lower Yuba River, California, in 1986.

	Simpson Lane		Daguerre Pt. Dam		Garcia Gravel Pit	
Community Type	ft	%	ft	%	ft	%
Blue Oak/Digger Pine						
Woodland	0	0	1,522	1	100,941	35
Riparian Vegetation	68,094	78	150,125	72	129,692	44
Grassland/Agricultural	6,949	8	0	0	0	0
Hydraulic Mine Tailings	0	0	22,779	11	47,974	16
Urban-Agricultural/ Degraded Ruderal	12,027	14	33,194	16	13,851	5
Total	87,070	100	207,620	100	292,458	100
	Narrows		Total River			
Community Type	ft	%	ft	%		
Blue Oak/Digger Pine						
Woodland	41,457	97	143,920	23		
Riparian Vegetation	1,458	3	349,369	56		
Grassland/Agricultural	0	0	6,949	1		
Hydraulic Mine Tailings	0	0	70,753	11		
Urban-Agricultural/ Degraded Ruderal	0	0	59,072	9		
Total	42,915	100	630,063	100		

Table 22. Estimated extent of linear features along the lower Yuba River, California, during the early 1970's (USACOE 1977).

Community Type	Garcia Gravel Pit		Narrows	
	ft	%	ft	%
Blue Oak/Digger Pine				
Woodland	11,880	10.8	16,500	89.3
Riparian Vegetation	9,900	9.0	0	0.0
Grassland/Agricultural	10,560	9.6	0	0.0
Chaparral*	436	0.4	1,980	10.7
Hydraulic Mine Tailings	77,220	70.2	0	0.0
Urban-Agricultural/ Degraded Ruderal	0	0.0	0	0.0
Total	109,996	100.0	18,480	100.0

* Chaparral included with blue oak/ digger pine woodland plant community during the 1986 investigations.

Comparison of current conditions with those of the early 1970s is made with caution, however. The stabilizing of streamflow following completion of New Bullards Bar Dam appears to have expanded the riparian community of the Garcia Gravel Pit Reach and may have affected the remaining reaches downstream in a similar manner.

Conclusions

Studies of the existing riparian plant community indicate it is only minimally benefiting the fishery. For example, most of the stream channel does not receive any shade from overhanging vegetation. The existing riparian community should be enhanced to provide benefits to fish as well as wildlife.

One such manner of riparian habitat improvement could be provided through transfer of uncompleted wildlife mitigation for impacts caused by Bullards Bar Reservoir to the lower Yuba River. Such mitigation could include land acquisition and enhancement of riparian vegetation. *very diff*

As a result of riparian investigations of the lower Yuba River, the value of stream side riparian and adjacent wildlife habitat has become very evident. The DFG recommends that the YCWA provide funds for acquisition of acreage of lands adjacent to the Yuba River below Englebright Dam as an alternative to the wildlife habitat mitigation provisions of the Agreement between DFG and the YCWA for New Bullards Bar. Such land should be operated for habitat protection and fish and wildlife oriented recreation by DFG with annual funds for habitat improvement and protection provided by the YCWA.

YCWA project has not decreased riparian. why should YCWA pay?
 Ppl of Beaks riparian report says: "The stabilizing of streamflow following completion of New Bullards Bar Dam has influenced the riparian community of the lower river. With the increased stabilization of river flow the riparian community has expanded."

Removal of riparian vegetation, due to its value for food production (terrestrial insects) for juvenile salmon and steelhead as well as nutrient input to the river system and its use by many wildlife species, should be carefully evaluated to assure no net loss to protect fish and wildlife resources. Riparian vegetation is included in the California Fish and Game Commission's definition of wetland vegetation and compensation must be sought in line with Commission policy. Programs for restoration and improvement of riparian habitat should be implemented.

Who pays??

Beaks riparian report (Pg 17) says that

in 1970s riparian represented 90%; now it's 44%.

These were 2 different studies, however. why didn't DFG compare criteria between COE & BEAK.

PUBLIC RECREATION AND ACCESS

What does this have to do
with DFG managing
fish & wildlife?

Current recreational use and access of the Yuba River is severely limited due to poor access. Total angling use in 1962 on the lower Yuba River was estimated to be 19,400 angler-days (DFG 1965a). Historic legal access sites include the access road to the gravel plant on the north side of the river at the Highway 20 bridge crossing, at Hallwood Avenue approximately 4.5 mi downstream of Daguerre Point Dam, and from the Feather River. Limited access is available across the University of California property and various private properties.

The Highway 20 bridge access is from a road that leads to a gravel plant located upstream of the bridge. This road is blocked some distance from the river by a gate operated by the gravel company. Foot access beyond this gate is generally permissible. However, parking is virtually nonexistent along this road.

Hallwood Avenue is a county road that ends at the edge of the Yuba River channel. Parking is limited to the side of the road, and often conflicts with adjacent agricultural interests. Restrictive signing prohibiting parking and access, barriers, and piles of agricultural waste further restrict parking and confuse the public as to their right to access the river.

Boat access to the Yuba River is possible from the Feather River. Two boat ramps located on the Feather River just upstream of the confluence with the Yuba River provide access to the Yuba River. Depending on flows, boats can navigate the Yuba River upstream to Daguerre Point Dam. From Marysville, access is available on foot through the River Front Park.

Public recreation and the fisheries resources of the Yuba River are capable of sustaining additional recreational use. To provide for such use, access sites for boat launching and takeout should be developed. One such site could be developed in conjunction with construction of the proposed new Highway 20 bridge near Smartville. Three additional sites could provide much of the launch and takeout necessary to provide adequate access. These additional sites could be located at Rose Bar, Daguerre Point Dam, and Hallwood Avenue.

Conclusions

Public access to the Yuba River is limited. Walk in access is limited and boat launching and takeout facilities do not exist. Boats must be hand carried to the river over considerable distance at all current Yuba River access sites. Boat launching facilities located on the Feather River at Marysville and Yuba City allow access to the Yuba River between Daguerre Point Dam and the Feather River only if flows are sufficient.

This is what people want. Why have another Feather River fishery?

*This statement seems in conflict w/ opening
statements about how bad the fisheries resources are in
state*

The fisheries resources of the Yuba River appear capable of sustaining additional recreational use.

Fishing access sites and boat launching and takeout facilities should be developed in the general areas of Rose Bar, the new Highway 20 bridge crossing, Daguerre Point Dam, and Hallwood Avenue.

INSTREAM FLOW AND MANAGEMENT RECOMMENDATIONS

DFG's management goals for the lower Yuba River are to optimize chinook salmon, steelhead trout, and American shad habitat conditions and populations. Fall- and spring-run chinook salmon are emphasized due to their significant value to sport and commercial fishing interests. However, species needs vary with life stage and the time of year, and, consequently, specific species life stages are emphasized during particular periods to adequately address the over all needs of the anadromous species in the lower Yuba River.

When evaluating instream needs and formulating flow regimes, a variety of factors and competing species life stage needs must be considered and integrated. Water temperature characteristics, the relationship between physical habitat availability and streamflow, water quality, channel stability and spawning gravel, migration barriers and fish entrainment, riparian vegetation, and effects of water project operations on flow and temperature are among the factors which should be considered when developing flow regimes to optimize habitats in the lower Yuba River. The analyses below consider the lower Yuba River's water temperature characteristics, the relationship between physical habitat availability and streamflow, and water availability.

Water temperatures in the lower Yuba River are affected by the operations of Englebright and New Bullards Bar reservoirs. Although constructed with an adjustable intake, operation of the New Bullards Bar project has not resulted in the water temperature benefits anticipated. Operation of the enlarged project has had little effect on downstream river temperatures from mid-December through early March. However, water temperatures tend to be increasingly warmer as spring progresses. On-the-other-hand, water temperatures tend to be cooler from early July through mid-December than they were before the dam was enlarged. DFG *in part* *NEW* makes the following temperature recommendations.

Water temperatures during the mid-October through March period should not exceed the daily average of 56.0°F at Daguerre Point Dam and 57.0°F at the Marysville gage during normal and wet water years. These criteria meet preferred temperature requirements of salmonids using the river during this period. They also comply with the Basin Plan (5A) requirements for the Sacramento River between Keswick Dam and Hamilton City (RWQCB 1975), and the Upper Sacramento River Fisheries and Riparian Advisory Council (1989) recommendations.

XX Water temperatures at the Marysville gage during normal and wet water years should not exceed the daily average of 60.0°F in April and May and 65.0°F in June. The May and June temperatures primarily benefit American shad, and occur at the upper range of preferred steelhead rearing.

L F + d. d. say "and do exceed juvenile salmon & steelhead preferred temperature"

To meet the various species life stage needs during July and August, water temperatures at Daguerre Point Dam should not exceed the daily average of 65.0°F. During September, the daily average should not exceed 65.0°F at the Marysville gage. For steelhead, 60.0°F is the maximum preferred in the summer period, while 65.0°F is within the low stress range identified by Rich (1987). The daily average water temperature at the Marysville gage during early October should not exceed 60.0°F. The July and August temperatures are designed to meet the needs of juvenile steelhead in the Garcia Gravel Pit and Daguerre Point Dam river reaches, since the greatest amount of juvenile habitat occurs in these two reaches. In addition, these temperatures will provide suitable conditions for adult spring-run chinook salmon holding in the Narrows Reach. The September-October temperatures will ensure suitable conditions for migrating adult salmonids.

Daily maximum water temperatures should not exceed the daily average temperature recommended above by more than 2°F for more than 8 h in any 24-h period during any month of the year.

Evaluation of existing temperatures indicate that river temperatures are often at or above salmon, steelhead, and/or shad life stage preferred ranges. Operation of Englebright, New Bullards Bar, and other upstream reservoirs should be evaluated and operational criteria developed to improve temperature conditions in the lower Yuba River.

Water temperature modeling on the lower Yuba River indicates that downstream temperature increases are influenced by air temperature and the river flow/diversion ratio. The greatest temperature increases occur during a warm June with an Englebright Dam release of 245 cfs. The effects of water diversion are most pronounced with a 500 or 1,000 cfs diversion and 245 cfs passing downstream of Daguerre Point Dam. Minimum change occurs during a cool November with a 3,000 cfs release. July through September water temperatures were not simulated during this investigation.

Results of the PHABSIM analyses of the physical habitat WUA/river discharge relationships indicate that the preferred physical living space requirements for fall- and spring-run chinook salmon, steelhead trout, and American shad species life stages are optimized by the following flow regime:

<u>Time period</u>	<u>River discharge at the Marysville gage (cfs)</u>
October 15-March 31	700
April 1-30	1,000
May 1-31	2,000
June 1-30	1,500
July 1-October 14	250-450

Incorrect. These flows take into account more than just "living space requirements"

Evaluating these river flows and existing and predicted river temperatures indicate that favorable water temperatures would occur during all periods except during the July to mid-October period when possible high temperatures would adversely affect the salmon and steelhead populations. Fish growth is reduced for all cold-water fishes at temperatures greater than 68.0°F while the upper lethal limit is 75.0°F for steelhead trout (Bell 1986).

Water temperatures downstream of Daguerre Point Dam during the July to mid-October period can increase rapidly depending upon diversion rates. Water temperatures not exceeding 65.0°F at Daguerre Point Dam during July and August, however, should not increase significantly downstream through the Daguerre Point Dam reach for maintenance of juvenile steelhead trout if adequate flows are provided. These adequate flows would also provide a measure of protection from high water temperatures near Marysville.

The flow of 450 cfs at the Marysville gage is recommended for the months of July, August, September, and October 1-14, respectively. This flow occurs within the range of flows identified as providing maximum juvenile steelhead trout habitat in run/glide habitat within the Garcia Gravel Pit and Daguerre Point Dam reaches and may achieve the recommended temperatures at Marysville better than flows of a lesser value. However, this flow recommendation is made in the absence of temperature studies for this summer period that would allow a definitive assessment of the temperature/flow relationship. Under this flow recommendation, flows upstream of Daguerre Point Dam could range up to 1,535 cfs during this period due to releases to satisfy offstream diversions. Associated with these flows, physical habitat for young steelhead trout and American shad may be reduced by an unspecified amount and water temperatures may be reduced to below optimum in this area. Any adverse impacts should be reduced by redeveloping juvenile steelhead physical habitat upstream of Daguerre Point Dam.

In view of the chinook salmon, steelhead trout, and American shad life stage requirements, the species life stage WUA/discharge indices, and river water temperatures, DFG recommends the following minimum flow regime be maintained in the lower Yuba River during normal and wet water years:

<u>Time period</u>	<u>River discharge at the Marysville gage (cfs)</u>
October 15-March 31	700
April 1-30	1,000
May 1-31	2,000
June 1-30	1,500
July 1-October 14	450

Flows too high (up to 1,500) so DFG wants to provide physical habitat. What about reducing spring flows??

it needs check this.

Analysis of the annual flow at Smartville indicates that the lower Yuba River's average annual unimpaired flow equals or exceeds 2,332,730 AF 46% of the time. Thus, this average annual value is a good indicator of the long-term average water supply in the lower Yuba River. The recommended flow regime at Marysville (599,614 AF) represents only 25.7% of this quantity (Table 23).

Table 23. Estimated Yuba River mean monthly unimpaired flow at Smartville for the 63-year period 1921-1983, actual flow at Marysville gage for the 1969-1988 period, and proposed minimum flow regime at Marysville, California. Flows are in acre-feet with cfs in parenthesis.

Month	Unimpaired flow at Smartville 1921-1983*	Actual flow at Marysville 1969-1988+	Proposed minimum flow at Marysville
Oct 1-14	15,800 (569)	34,739 (1,251)	12,496 (450)
Oct 15-31	19,200 (569)	42,183 (1,251)	23,604 (700)
Nov	96,790 (1,627)	101,159 (1,700)	41,654 (700)
Dec	203,440 (3,309)	175,980 (2,862)	43,042 (700)
Jan	263,490 (4,285)	277,498 (4,513)	43,042 (700)
Feb	287,700 (5,180)	276,357 (4,976)	38,877 (700)
Mar	316,490 (5,147)	261,265 (4,249)	43,042 (700)
Apr	375,460 (6,310)	187,322 (3,148)	59,505 (1,000)
May	426,510 (6,936)	136,259 (2,216)	122,977 (2,000)
Jun	224,570 (3,774)	107,288 (1,803)	89,258 (1,500)
Jul	58,380 (949)	78,705 (1,280)	27,670 (450)
Aug	24,600 (400)	90,450 (1,471)	27,670 (450)
Sep	20,290 (341)	88,603 (1,489)	26,777 (450)
Total	2,332,730	1,857,808	599,614

* Source: DWR (1987a) (also see Table 4).

+ Source: USGS, Water Resource Data - California, water years 1969 through 1988.

it needs totally ignored

Comparing the lower Yuba River's proposed flows at Marysville with the river's annual unimpaired flow (at Smartville) for the 63-year period indicates that the total annual flow recommended for fishery purposes is exceeded about 98% of the years. Hence, on the average, there is insufficient water in the Yuba River to meet fishery needs in only 2 out of every 100 years.

In addition, comparing the proposed July through mid-October flows to estimates of mean monthly unimpaired flow at Smartville for the period 1921-1983 indicates the proposed flow of 450 cfs during August, September, and October exceeds the estimated mean monthly unimpaired flow requiring flow augmentation of 10,657 AF (Table 23, Figure 34).

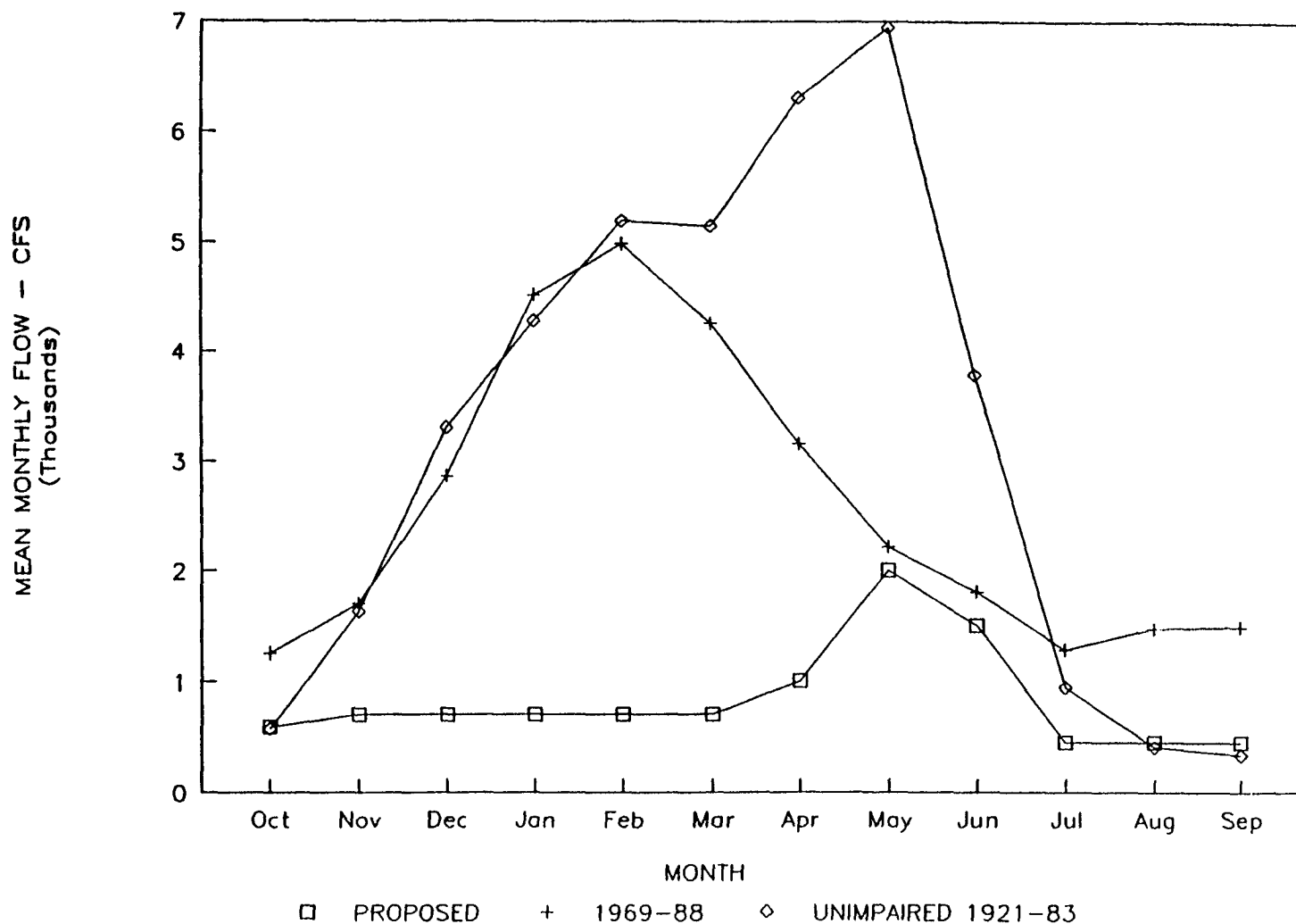


Figure 34. Proposed minimum fisheries flow regime at Marysville compared with estimated mean monthly unimpaired flow at Smartville (gage 11419000) for water years 1921-1983 and actual flow recorded at Marysville (gage 11421000) for water years 1969-1988, lower Yuba River, California.

Since flow in the lower Yuba River is impaired by water project operations and diversions, comparison of the actual and recommended flows at Marysville provides a more representative evaluation than one using unimpaired flows. Comparing the recommended monthly flow regime with the actual average monthly flow at Marysville indicates that the proposed monthly flows are exceeded during all months of the year. Thus, flow augmentation is not needed during any period of the year as long as project operations remain relatively the same as they are now.

Combining the recommended total annual instream flow requirements (599,614 AF) and the existing riparian, miscellaneous appropriative, and active contractual offstream requirements (265,221 AF) indicates that 864,835 AF are needed each year to meet fishery instream and various offstream needs. Analysis of the unimpaired annual flow at Smartville indicates that the total water needs are exceeded about 94% of the time. In other words, on the average there is insufficient flow in the lower Yuba River during only 6 out of every 100 years to meet in- and offstream needs.

Although not evaluated in these studies, attraction flows may be necessary to induce fall-run chinook salmon and steelhead trout into the lower Yuba River. Additional studies should be implemented to evaluate attraction flows and results used to refine the above flow recommendations.

*-this
value be stated
in summary, if
it isn't*

The above analysis assumes that sufficient water of suitable temperature is available to meet the recommended flow requirements. This may not be the case. Insufficient cool water may be stored in the upstream project to fully meet downstream temperature and flow requirements. Hence, the availability of water of suitable temperature needs to be evaluated. Therefore, DFG recommends that Englebright and New Bullards Bar reservoirs' water temperature, water availability, and operational procedures and criteria be modeled and evaluated. Additional temperature studies of the water temperature/flow relationship below Englebright Dam are needed for the summer months of July through September since simulations were not conducted during these investigations. These data should be used to refine the above recommended flow regime.

When developing flow recommendations for California streams, it is customary to develop "dry" water year criteria. If only the WUA/discharge indices, offstream needs, and water availability information are considered, on the surface it would appear that dry year criteria should be developed for "extremely dry" years. However, if water temperature and availability of water of suitable temperature is considered, it becomes more apparent that dry year criteria are needed. Once the recommended reservoir water availability and temperature and project operations modeling effort are completed, the following dry year criteria should be reviewed and modified as appropriate.

For the purpose of this analysis, a dry year is defined as a water year where the estimated unimpaired annual runoff is less than 50% of the 50-year average unimpaired runoff of the Yuba River in acre-feet at Smartville for the current water year as published annually in the May 1, Report of Water Conditions in California by DWR. In the event a dry water year is identified, reductions to fishery flows recommended by DFG and offstream diversions shall be made on an equal percentage basis. Such reductions shall be based on water available to permanent contracts existing on January 1, 1990. Post January 1, 1990 offstream contractual obligations and diversions shall be reduced to zero before reductions in fishery flows occur.

What does this mean?

Further, in the event a dry year occurs, the recommended daily water temperature defined in this report's water temperature section shall not apply.

Short-term daily flow fluctuations and flow reductions can occur at any time due to natural storm events, maintenance of flood reservation storage, hydroelectric power generation, and diversion requirements. Flow fluctuations and reductions can dewater salmonid redds, cause a net loss of spawning gravels, loss of juveniles through stranding, and disrupt angler access to fishing areas and angler catch rate.

Short-term daily streamflow fluctuations are defined as changes in the flow that occur on a regular daily basis generally associated with daily operations of hydroelectric power generation and deliveries for offstream diversion requirements. To avoid loss of aquatic productivity and to prevent fish stranding, it is recommended that daily flow fluctuations should not exceed 10% of the average flow within any 24-h period and weekly flow fluctuations should not exceed 20% of the average flow within any 7-d period at all times while New Bullards Reservoir and Englebright Reservoir are under control (i.e. no unregulated spills are occurring). For example, if the average flow for the period is 200 cfs, flows should not be less than 180 cfs or greater than 220 cfs; flows on a weekly basis should not be less than 160 cfs or greater than 240 cfs. Flow fluctuations should be measured at the USGS gage below Englebright and near Marysville.

Streamflow reductions are defined as planned reductions. Such reductions are generally associated with, but not limited to, the specified monthly flow schedule above, reservoir flood reservation requirements, deliveries to offstream diverters, water transfers and sales, and downstream salinity intrusion control. During all such flow reductions to prevent loss due to dewatered salmonid redds, net loss of spawning gravels, and loss of juveniles through stranding, the ramping rate shall be gradual, not exceeding 30% of the existing initial flow during any 24-hour period and subject to stranding studies.

It was no more than 10% of existing initial flow during any 24-hour period

from 24 hr period before

To further minimize the impacts to chinook salmon and steelhead trout spawning from flow reductions during the period October 15 through February, the following interim schedule, subject to any stranding studies, is recommended to reduce the negative impacts of dewatered redds, net loss of spawning gravels, and loss of juveniles to stranding. In the event that during the period October 15 through February, the 7-d average flow released from Englebright Dam exceeds 800 cfs (except in the event of flood control releases) the previously described monthly minimum flow schedule shall be modified as follows: (1) if the average flow for the preceding 7-d period exceeds 800 cfs but is less than 1,000 cfs, the minimum flow should be 800 cfs from the date of occurrence through February at the Marysville gage, (2) if the average flow for the preceding 7-d period exceeds 1,000 cfs but is less than 1,500 cfs, the minimum flow specified should be 1,000 cfs from the date of occurrence through February at the Marysville gage, and (3) if the average flow for the preceding 7-d period exceeds 1,500 cfs, then the minimum flow specified should be 1,500 cfs from date of occurrence through February at the Marysville gage.

new

For maintenance of American shad angler success, a weekly flow reduction not greater than 200 cfs should occur during May 1 through May 31, and not greater than 150 cfs during June 1 through June 30, as measured at the Marysville gage.

The information developed during these investigations indicate that salmon and steelhead fry and juvenile habitat in the lower Yuba River currently is less than optimum. Channel narrowing and degradation have acted to reduce available habitat for fry and juvenile salmonids. Habitat improvement projects should be implemented and should include construction of shallow "rearing" areas and "braided" channels designed to optimize habitat requirements for fry and juveniles. Stocking of additional steelhead fry should be considered to increase steelhead production.

ACKNOWLEDGMENTS

Funding for the Lower Yuba River Fisheries Investigations came from the Environmental License Plate Fund through appropriations to the Streamflow Requirements Program, California Department of Fish and Game, contained in Assembly Bill No. 723 of 1985, Chapter 1259.

Beak Consultants, Incorporated was the primary contractor but utilized the efforts and technical expertise of several subconsultants who were responsible for the conduct on one or more of the technical studies that comprised the Lower Yuba River Fisheries Investigations. Thomas R. Payne and Associates conducted the water temperature modeling and instream flow studies for chinook salmon. Philip Williams and Associates performed the studies on channel stability and assessed spawning gravels. Beak conducted the other technical studies.

Special thanks are extended to Mike Aceituno of the U.S. Fish and Wildlife Service for the analysis of instream flow using PHABSIM for steelhead trout.

Department of Fish and Game staff who provided supervision, direction, and review include Jerry Mensch, Mike Mainz, John Nelson, John Turner, Bob Orcutt, Gary Smith, Cindy Chadwick, Dan Odenweller, Fred Meyer, and Jim Schuler. Lynn Wixom compiled this report.

REFERENCES

- Aceituno, M.E., G.E. Smith, G. Ging, and D.M. Ward. 1985. Habitat preference criteria for eastern Sierra Nevada streams: Family Salmonidae. U.S. Department of the Interior, Bureau of Land Management Technical Report BLM/CA-930/85-1, 30 pp.
- Adler, L.L. 1980. Adjustment of Yuba River, California, to the influx of hydraulic mining debris, 1849-1979. MA Thesis, Geography Dept., UCLA.
- American Fisheries Society. 1980. A list of common and scientific names of fishes from the United States and Canada. Special Publication No. 12, 174 pp.
- Anonymous. 1982. Investing for prosperity. State of California, the Resources Agency.
- Beak Consultants, Inc. 1976. Benefits and impacts of the Marysville Lake Project on fish and wildlife. A report prepared for the U.S. Army Corps of Engineers, Sacramento District, 275 pp + appendices.
- Bell, M.C. 1986. Fisheries handbook of engineering requirements and biological criteria. Fish Passage Development and Evaluation Program, U.S. Army Corps of Engineers, North Pacific Division. Portland, Oregon, 290 pp.
- Boles, G.L., S.M. Turek, C.D. Maxwell, and D.M. McGill. 1988. Water temperature effects on chinook salmon (Oncorhynchus tshawytscha) with emphasis on the Sacramento River: a literature review. Calif. Dept. of Water Resources, 44 pp.
- Bovee, K.D. 1978. Probability-of-use criteria for the family Salmonidae. Instream Flow Information Paper 4, U.S. Fish. Wild. Serv., FWS/OBS-78/07, 80 pp.
- Bovee, K.D. 1982. A guide to stream habitat analysis using the instream flow incremental methodology. Instream Flow Information Paper 12, U.S. Fish. Wild. Serv., FWS/OBS-82/26, 248 pp.
- Bovee, K.D. 1986. Development and evaluation of habitat suitability criteria for use in the instream flow incremental methodology. Instream Flow Information Paper 21, U.S. Fish. Wild. Serv. Biol. Rept. 86(7), 235 pp.
- Bovee, K.D. and R.T. Milhous. 1978. Hydraulic simulation in instream flow studies: Theory and techniques. Instream Flow Information Paper No. 5. Fort Collins, Colorado, Cooperative Instream Flow Service Group, FWS/OBS-78/33.

Brown, L.R. and P.B. Moyle. 1981. The impact of squawfish on salmonid populations: A review. North American Journal of Fisheries Management 1:104-111.

Brusven, M.A. 1977. Effects of sediments on insects. In D.L. Kibbee, editor. Transport of granitic sediments in streams and its effects on insects and fish. U.S. Forest Service. Forest, Wild., and Range Expt. Sta. Bull. 17, University of Idaho, Moscow.

Buchanan, T.J. and W.P. Somers. 1969. Discharge measurements at gaging stations. Techniques of water resources investigations of the United States Geological Survey, 65 pp.

Burger, C.V., D.B. Wangaard, R.L. Wilmot, and A.N. Palmisano. 1982. Salmon investigations in the Kenai River, Alaska, 1979-1981. In R.F. Raleigh, W.J. Miller, and P.C. Nelson. 1986. Habitat suitability index models and instream flow suitability curves: chinook salmon. U.S. Fish. Wild. Serv. Biol. Rep. 82(10.122), 64 pp.

California Department of Fish and Game (DFG). 1965a. Letter to California Department of Water Resources; subject - Yuba County Water Agency, Yuba River Development (Davis-Grunsky) Project Formal Feasibility Report Review. August 27, 1965.

California Department of Fish and Game (DFG). 1965b. California Fish and Wildlife Plan. Volumes I, II, and III. California Office of State Printing, Sacramento, California.

[California Department of Fish and Game (DFG). 1975. Draft Report, Oroville Project fish investigation program (1968-1975), May 30, 1975. A study by the Department of Fish and Game for the Department of Water Resources in accordance with Federal Power Commission License No. 2100, 287 pp.

California Department of Fish and Game (DFG). 1984. Office files for Yuba River. Memorandum dated March 2, 1984. Ron Rogers - Yuba River steelhead run during winter of 1976-77. Region II Office, Rancho Cordova, CA.

California Department of Fish and Game (DFG). 1987a. Office files for Yuba River. Memorandum dated June 11, 1987. Lawrence G. Preston - South Yuba/Brophy Irrigation Diversion Study. Region II Office, Rancho Cordova, CA.

NEW California Department of Fish and Game (DFG). 1987b. Office files for Yuba River. Memorandum dated June 17, 1987. Lawrence G. Preston - Browns Valley Irrigation District's Diversion Study. Region II Office, Rancho Cordova, CA.

California Department of Fish and Game (DFG). 1988. Office files for Yuba River. Memorandum dated November 18, 1988. Deborah Konhoff - South Yuba/Brophy Diversion Study. Region II Office, Rancho Cordova, CA.

California Department of Fish and Game (DFG). 1990. Determination of habitat preference for upper Sacramento River chinook salmon, Final Report, Project F-51-R, 43 pp + appendices.

California Department of Water Resources (DWR). 1966. Contract between State of California Department of Water Resources and Yuba County Water Agency for Recreation and Fish Enhancement Grants under the Davis-Grunsky Act, Contract No. D-GGR15.

California Department of Water Resources (DWR). 1985. Water conditions in California. California Cooperative Snow Surveys, Bulletin 120-85, Report 4, May 1, 1985, 16 pp.

California Department of Water Resources (DWR). 1987a. California Central Valley unimpaired flow data. Division of Planning, Second Edition, February 1987, 38 p.

California Department of Water Resources (DWR). 1987b. Water conditions in California. California Cooperative Snow Surveys, Bulletin 120-87, Report 4, May 1, 1987, 16 pp.

California Regional Water Quality Control Board (RWQCB). 1975. Water quality control plan report: Sacramento River Basin (5A), Sacramento-San Joaquin Delta Basin (5B), San Joaquin Basin (5C). State Water Resources Control Board, Regional Water Quality Control Board, Central Valley Region (5), Volume 1, 228 pp + appendices.

California Water Resources Control Board (CWRCB). 1987. Toxic substances monitoring program. Data base description. June 1987. California State Water Resources Control Board, Sacramento, 27 pp.

Carlander, K.D. 1969. Handbook of freshwater fishery biology, Volume 1. The Iowa State University Press, Ames, Iowa.

Chambers, J.S. 1956. Research relating to study of spawning grounds in natural areas. Fish Passage Development and Evaluation Program, Progress Report No. 5, 1956. U.S. Army Corps of Engineers, North Pacific Division, Portland Oregon, pp. 88-94.

Envirosphere Co. 1988. Lower Mokelumne River fisheries study. Report prepared for the California Department of Fish and Game, Region II.

- Evans, W.A., and B. Johnston. 1980. Fish migration and fish passage. U.S.D.A. Forest Service, EM-7100-12, Washington, D.C., 63 pp.
- Fisher, C.K. 1979. No guarantees for minimum water flows for fish and wildlife. Outdoor California, 40(5):10-11.
- Fry, D.H. 1961. King salmon spawning stocks of the California Central Valley, 1940-1959. California Fish and Game, 47(1):55-71.
- Gilbert, G.K. 1917. Hydraulic mining debris in the Sierra Nevada. U.S. Geological Survey Prof. Paper 105, 155 pp.
- Hall, F.A., Jr. 1977. A discussion of Sacramento squawfish predation problems at Red Bluff Diversion Dam. DFG office memorandum to Bay-Delta Fish Facilities Project Predation Study Files, August 4, 1977.
- Hall, F.A., Jr. 1979. An evaluation of downstream migrant chinook salmon (Oncorhynchus tshawytscha) losses at Hallwood-Cordua Fish Screen. California Dept. Fish and Game, Anadromous Fisheries Branch Admin. Report No. 79-5, 17 pp. + appendices.
- Hampton, M. 1988. Development of habitat preference criteria for anadromous salmonids of the Trinity River. U.S. Dept. Int., Fish Wildl. Serv., Div. Ecol. Serv., Sacramento, CA, 93 pp.
- Kendall, R.L. 1988. Taxonomic changes in North American trout names. Trans. Am. Fish. Soc., 117:321.
- Kjelson, M.A. and P.L. Brandes. 1988. Determine survival and productivity of juvenile chinook salmon in the Sacramento-San Joaquin Estuary. U.S. Fish Wildl. Serv., Annual Progress Report, 9/30/88, Fisheries Assistance Office, Stockton, CA, 56 pp.
- Kurko, K.W. 1977. Investigations on the amount of potential spawning area available to chinook, pink, and chum salmon in the upper Skagit River, Washington. MS Thesis, Univ. Wash., Seattle, 76 pp.
- LaCaro, F., S.P. Haynes, D. Watkins, and C. Reiner. 1981. Toxic substances monitoring program, 1981. California State Water Resources Control Board, Water Quality Monitoring Report No. 82-3TS.
- Leim, A.H. 1924. The life history of the shad, Alosa sapidissima (Wilson), with special reference to the factors limiting its abundance. Contrib. Canadian Biol. N.S. 2(11):163-284.

- Massmann, W.H. 1952. Characteristics of spawning areas of shad, Alosa sapidissima (Wilson) in some Virginia streams. Trans. Am. Fish. Soc. 81:78-93.
- Meinz, M. 1979. Young American shad (Alosa sapidissima) ecology. Final Report, Job No. 4, Calif. Dept. Fish and Game, Anadromous Fisheries Conservation Act, AFS-17, 17 pp.
- Meinz, M. 1981. American shad, (Alosa sapidissima), sport fishery in the Sacramento River system 1976-78: Catch and effort. Calif. Dept. Fish and Game, Anad. Fish. Br. Admin. Report 81-1, 19 pp.
- Milhous, R.T., D.S. Wegner, and T. Waddle. 1984. User's guide to the Physical Habitat Simulation System. Instream Flow Information Paper 11. Cooperative Instream Flow Service Group, Fort Collins, Colorado, FWS/OBS-81/43, 256 pp.
- Moyle, P.B. 1976. Inland fishes of California. Univ. Calif. Press, Berkeley, 405 pp.
- Pacific Gas and Electric Co. (PG&E). 1989. Narrows Project (FERC 1403), Application for new license for major project-existing dam.
- Painter, R.E., L.H. Wixom, and S.N. Taylor. 1977. An evaluation of fish populations and fisheries in the post-Oroville Project, Feather River. A report submitted to the Department of Water Resources in accordance with Federal Power Commission License No. 2100. Calif. Dept. Fish and Game, 56 pp.
- Painter, R.E., L.H. Wixom, and M. Meinz. 1979. American shad management plan for the Sacramento River drainage. Final Report, Job No. 5, Calif. Dept. Fish and Game, Anadromous Fisheries Conservation Act, AFS-17, 22pp.
- Preston, L.G. 1983. Dry Creek (Yuba County). In R. Reavis, (ed.). 1986. Chinook salmon spawning stocks in California's Central Valley, 1983. California Department of Fish and Game, Anad. Fish. Br. Admin. Report No. 86-01.
- Raleigh, R.F., T. Hickman, R.C. Solomon, and P.C. Nelson. 1984. Habitat suitability information: rainbow trout. U.S. Fish Wildl. Serv. FWS/OBS-82/10.60, 64 pp.
- Raleigh, R.F., W.J. Miller, and P.C. Nelson. 1986. Habitat suitability index models and instream flow suitability curves: chinook salmon. U.S. Fish Wildl. Serv. Biol. Rep. 82(10.122), 64 pp.

- Reavis, R., Jr. 1984. Annual report chinook salmon spawning stocks in California's Central Valley, 1982. Anad. Fish. Br. Admin. Report No. 84-10.
- Reavis, R., Jr. 1986. Annual report chinook salmon spawning stocks in California's Central Valley, 1983. Anad. Fish. Br. Admin. Report No. 86-01.
- Reiser, D.W. and T.C. Bjornn. 1979. Habitat requirements of anadromous salmonids. In Influence of forest and rangeland management on anadromous fish habitat in the western United States and Canada. USDA, Forest Service, General Technical Report PNW-96.
- Remington, R.D., and M.A. Schork. 1970. Statistics with applications to the biological and health sciences. Prentice-Hall, Englewood Cliffs, NJ, 418 pp.
- Rich, W.H., P.R. Needham, A.C. Taft, and R. Van Cleve. 1944. A preliminary report on the fishery resources of California in relation to the Central Valley Project, 20 pp. A report prepared jointly by the U.S. Fish and Wildlife Service and the Calif. Division of Fish and Game, Stanford Univ., August 19, 1944.
- Rich, A.A. 1987. Establishing temperatures which optimize growth and survival of the anadromous fishery resources of the lower American River. Prep. for McDonough, Holland and Allen, Sacramento, California, 25 pp.
- Skinner, J.E. 1962. An historical review of the fish and wildlife resources of the San Francisco Bay area. Calif. Dept. Fish and Game, Sacramento, Water Project Branch Rept. No. 1, 225 pp.
- Somerville, P.N. 1958. Tables for obtaining non-parametric tolerance limits. An. Math. Stat. 29:599-601.
- Stevens, D.E. 1966. Distribution and food habits of the American shad, Alosa sapidissima, in the Sacramento-San Joaquin Delta. In Ecological studies of the Sacramento-San Joaquin Delta. Calif. Dept. Fish and Game, Fish. Bull. 136:97-107.
- Suchanek, P.M., R.P. Marshall, S.S. Hale, and D.C. Schmidt. 1984. Juvenile salmon rearing suitability criteria. In R.F. Raleigh, W.J. Miller, and P.C. Nelson. 1986. Habitat suitability index models and instream flow suitability curves: chinook salmon. U.S. Fish Wild. Serv. Biol. Rep. 82(10.122), 64 pp.

- Taylor, S.N. 1974. King (chinook) salmon spawning stocks in California's Central Valley, 1972. Anad. Fish. Br. Admin. Report 74-6.
- Theurer, F.D., K.A. Voos, and W.J. Miller. 1984. Instream water temperature model. Instream Flow Information Paper 16. U.S. Fish Wild. Serv. FWS/OBS-84/15, 335 pp.
- Thompson, K. 1972. Determining streamflows for fish life. In Proc. Instream Flow Req. Wkshp., pp. 31-46. Portland, OR, March 15-16, 1972.
- Trihey, E.W., and D.L. Wegner. 1981. Field data collection procedures for use with the physical habitat simulation system of the Instream Flow Service Group, Ft. Collins, CO, 151 pp.
- Upper Sacramento River Fisheries and Riparian Habitat Advisory Council. 1989. Upper Sacramento River Fisheries and Riparian Habitat Management Plan. A report prepared for the Resources Agency, State of California, January 1989, 158 pp.
- U.S. Army Corps of Engineers (USACOE). 1977. DEIS: Marysville Lake; Yuba River, California. Sacramento District, 325 pp.
- U.S. Department of Commerce. 1972. Climatography of the United States, No. 86-4.
- U.S. Environmental Protection Agency (USEPA). 1986. Quality criteria for water 1986. EPA 440/5-86-001-Update #2.
- U.S. Geological Survey (USGS). 1968-1988. Water resources data for California. Multiple water years. Volume 4, Northern Central Valley basins and the Great Basin from Honey Lake Basin to Oregon stateline.
- Vincent-Lang, D., A. Hoffman, A. Bingham, and C. Estes. 1984. Habitat suitability criteria for chinook, coho, and pink salmon spawning in tributaries of the Middle Susitna River. In R.F. Raleigh, W.J. Miller, and P.C. Nelson. 1986. Habitat suitability index models and instream flow suitability curves: chinook salmon. U.S. Fish Wild. Serv. Biol. Rep. 82(10.122), 64 pp.
- Vogel, D.A. 1982. Preferred spawning velocities, depths, and substrates for fall chinook salmon in Battle Creek, California. In R.F. Raleigh, W.J. Miller, and P.C. Nelson. 1986. Habitat suitability index models and instream flow suitability curves: chinook salmon. U.S. Fish Wild. Serv. Biol. Rep. 82(10.122), 64 pp.

Walburg, C.H. 1960. Abundance and life history of shad in St. Johns River, Florida. U.S. Fish Wild. Ser. Fish. Bull. 60(177):487-501.

Wooster, T.W. 1963. Fish and wildlife in relation to proposed water developments on the lower Yuba River. Calif. Dept. Fish and Game, Water Proj. Br. Admin, Rept. No. 63-2, 61 pp + appendices.

Wooster, T.W., and R.H. Wickwire. 1970. A report on the fish and wildlife resources of the Yuba River to be affected by the Marysville Dam and Reservoir and Marysville Afterbay and measures proposed to maintain these resources. Calif. Dept. Fish and Game, Environmental Serv. Admin. Rept. No. 70-4, 74 pp + appendices.

APPENDIX I

LOWER YUBA RIVER DISCHARGE
FOR 1969 TO 1988
WATER YEARS

Table I-1.
Yuba River discharge (cfs) at USGS gage station 11418000, below Englebright Dam, near Smartville.*

Water Year	Month											
	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1969												
Mean	363	616	1235	8875	8314	3197	5385	7293	2064	503	477	297
Max	625	670	4300	32400	12200	7580	8540	12500	6220	720	500	410
Min	0	555	565	1060	6700	1650	2660	2180	700	350	425	275
1970												
Mean	343	373	1097	14750	4029	3568	981	2524	1259	1035	1740	2056
Max	380	388	10000	76400	6350	5930	3380	3620	1990	1600	2330	3550
Min	297	356	353	700	2460	722	726	943	761	694	1290	224
1971												
Mean	2372	3202	4131	3809	3294	1795	2038	2223	4548	2945	2850	2422
Max	2670	3770	4920	4570	4080	9210	2920	3670	8800	3790	2900	3410
Min	2070	2580	3740	3080	1540	595	685	1520	3560	1300	2820	1470
1972												
Mean	1699	1911	2519	2281	1440	683	696	875	861	1377	2144	2453
Max	2060	2070	3540	2550	3910	806	899	900	879	1920	2730	2880
Min	1470	1490	1970	1540	580	630	631	854	775	707	1890	710
1973												
Mean	2752	2908	3041	4363	4222	4115	2427	1140	998	1347	1760	1875
Max	2780	3050	4000	7840	4370	4340	3610	1950	1030	1930	1840	1900
Min	2720	2760	2410	3340	4050	1630	1940	839	923	926	1280	1830
1974												
Mean	2083	4145	4870	7538	3950	6505	7739	3999	4069	2472	2646	416
Max	2350	8820	11100	20900	4170	24000	32100	5610	6060	2740	2770	565
Min	1590	2360	3550	4160	2510	4150	4160	1720	2220	2120	692	324
1975												
Mean	559	1653	3663	2588	1969	2779	3695	1944	3901	2142	2783	2806
Max	639	4180	4110	4130	4230	4200	4190	4180	6030	2840	2820	2830
Min	329	637	3410	1100	1080	1490	1540	1070	1450	1810	2110	2780
1976												
Mean	2730	2723	2313	974	524	584	437	636	609	594	497	526
Max	2830	2810	2740	1680	1030	2160	705	869	701	664	565	706
Min	1380	2500	1680	462	426	357	238	540	545	563	403	222
1977												
Mean	703	695	558	283	211	199	443	367	501	430	364	202
Max	711	707	704	376	245	224	565	519	548	498	413	281
Min	701	685	348	250	148	191	245	319	455	409	302	140
1978												
Mean	422	396	603	3384	3816	4622	4609	3695	1279	1806	2844	2839
Max	473	500	1790	9480	4290	7030	5630	4440	2080	2490	2870	2870
Min	241	313	315	535	2920	3500	4330	1480	842	864	2810	2760
1979												
Mean	1286	1039	1057	1763	2071	1181	634	1922	1303	1719	2220	2007
Max	2860	1070	1080	5470	3750	4160	1150	4280	1810	2220	2270	2320
Min	671	876	1020	1050	1790	604	552	608	1040	1410	2180	674

Table I-1, continued (below Englebright Dam).

Water Year	Month											
	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1980												
Mean	2005	1799	2256	6860	7851	4765	4099	2965	2787	3035	3140	3144
Max	2520	1830	3800	28200	21000	7410	4120	4180	3370	3380	3230	3160
Min	1550	1760	1800	2800	3310	4130	4020	2210	2380	2040	3010	3110
1981												
Mean	1683	1134	1371	858	789	1091	684	857	881	858	690	590
Max	3160	1160	1430	1140	1320	3290	1070	893	1050	872	1160	932
Min	590	1130	1140	513	597	604	614	751	851	836	551	480
1982												
Mean	636	2621	7364	6172	9155	5446	11950	7750	3849	2968	2856	2621
Max	1640	20900	42400	21900	32500	9070	29800	11200	5420	3200	3160	3760
Min	510	595	2640	4110	4060	4210	4950	5030	2350	2220	2820	676
1983												
Mean	1899	2719	3835	3185	5789	11680	5135	7159	9017	4034	2679	2198
Max	2910	3850	9960	5000	10900	30500	9140	11100	11900	7410	2740	2720
Min	1170	1990	2380	2660	4080	5700	4070	4130	5430	2390	2040	686
1984												
Mean	2520	3877	9787	5282	3382	2934	2006	1962	2468	2519	3104	2870
Max	2730	13600	31100	17300	4050	4060	2730	3370	3360	3040	3230	3740
Min	2300	2290	3910	3920	1910	2330	1430	1430	2230	2220	2690	1500
1985												
Mean	1359	1562	2128	1210	822	697	915	981	1152	1273	826	514
Max	2320	1880	2440	1780	2890	1800	1470	1020	1470	1720	996	666
Min	702	1060	1800	546	558	558	686	961	967	968	662	397
1986												
Mean	702	672	876	1479	17330	11410	3216	1663	1800	1977	1399	1904
Max	870	754	910	2360	87200	46300	6230	3690	4160	2340	1910	3400
Min	545	653	727	802	2360	5280	1350	1070	1060	1770	1130	1140
1987												
Mean	1130	823	672	827	856	805	679	933	968	796	1518	693
Max	1940	864	737	1050	2820	2390	1310	1100	1050	1460	1770	864
Min	600	765	624	630	575	606	267	810	805	670	1140	532
1988												
Mean	694	663	667	1259	1209	632	627	717	871	1401	1374	812
Max	815	735	794	1530	1540	664	745	829	1040	1580	1460	1370
Min	554	610	624	1050	611	617	537	620	664	979	1260	522

* Source: U.S. Geological Survey (USGS), Water Resources Data - California, water years 1969 through 1988.

Table 1-2.
Yuba River discharge (cfs) at USGS gage station 11421000, near Marysville.*

Water Year	Month											
	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1969												
Mean	242	492	1350	10890	10930	4266	6091	7432	1680	76	56	88
Max	480	736	5570	39900	17200	11000	9520	13000	6100	234	76	118
Min	29	362	460	1060	8590	2330	2870	2010	230	44	45	61
1970												
Mean	132	183	1360	17080	5134	4310	712	2020	767	477	1199	1837
Max	293	262	13300	90200	8900	7970	2740	3140	1770	959	1940	3270
Min	75	102	168	602	3390	1000	242	350	294	187	922	166
1971												
Mean	2125	2853	4352	4225	3520	2395	2022	1821	145	2458	2429	2197
Max	2370	4010	7690	5420	4320	12800	3100	3160	50	3380	2510	3110
Min	1850	2300	3910	3860	1700	668	873	1180	3170	1310	2360	1410
1972												
Mean	1476	1663	2455	2247	1737	782	498	462	418	893	1643	2196
Max	1810	1870	4460	2750	4430	972	850	521	450	1420	2240	2690
Min	1230	1250	1770	1700	903	595	271	352	392	270	1390	620
1973												
Mean	2603	2903	2901	5436	5643	4944	2449	716	575	909	1383	1671
Max	2680	3810	4083	12500	8280	6330	4310	1480	633	1450	1550	1760
Min	2520	2530	2290	3100	4610	2650	1480	449	545	478	1020	1550
1974												
Mean	1917	4385	5485	8754	4305	8346	8879	3686	3725	2113	2317	287
Max	2260	10000	14000	22800	5150	31400	8300	5120	5650	2400	2430	502
Min	1490	2090	3440	4660	3100	4750	230	1510	1990	1710	599	197
1975												
Mean	315	1418	3529	2655	2915	3870	1952	1576	3377	1729	2380	2664
Max	422	4020	4130	4660	8430	9490	5110	3510	5280	2340	2510	2740
Min	200	408	3220	1350	1610	1780	1720	810	1180	1420	1850	2530
1976												
Mean	2731	2568	2004	847	557	612	266	211	201	132	136	393
Max	2910	2860	2470	1350	802	2110	344	391	223	181	171	629
Min	1500	2260	1370	488	473	286	190	156	164	115	115	107
1977												
Mean	527	476	371	230	211	188	173	166	155	88	72	86
Max	656	509	502	394	263	228	200	206	183	153	87	111
Min	356	359	170	146	168	163	150	134	121	62	62	67
1978												
Mean	259	271	631	4080	4165	5232	4996	3211	861	1260	2230	2488
Max	294	356	1880	10800	5550	8830	7500	4580	1610	1780	2340	2570
Min	84	243	237	544	2980	3820	4510	1330	404	407	2180	2320
1979												
Mean	1125	850	922	1882	2705	1992	734	1502	815	1198	1725	1768
Max	2540	1190	1010	5730	5140	8940	1220	3570	1410	1650	1830	2080
Min	452	723	880	905	1820	875	425	310	526	909	1650	584

Table I-2, continued (near Marysville).

Water Year	Month											
	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1980												
Mean	1909	1686	2224	7796	9508	5559	4076	2736	2462	2638	2530	2900
Max	2420	1780	5230	33400	27500	8550	4530	3860	3020	2970	2660	3270
Min	1480	1610	1600	2660	3700	4460	3650	1970	2070	1800	2310	2650
1981												
Mean	1557	953	1293	1040	925	1435	617	354	355	318	263	422
Max	3080	981	1360	2790	1560	4070	1280	420	513	348	803	893
Min	405	930	983	588	679	713	289	238	269	265	165	269
1982												
Mean	485	2889	8336	7516	10900	7290	14280	7234	3483	2642	2624	2629
Max	1560	22100	53900	24200	43800	16600	35500	10400	5000	2970	2860	3760
Min	369	382	2770	4750	4500	5370	6190	4770	2210	2050	2530	714
1983												
Mean	1874	2720	4382	4159	7671	15100	6098	7276	8633	3735	2425	2209
Max	3240	5650	13900	10400	17500	38000	10600	10500	11400	7020	2510	2920
Min	1020	1820	2980	2850	4700	7410	4530	4850	4950	2140	1770	535
1984												
Mean	2575	4475	11430	5997	4163	3504	2073	1582	2106	2124	2829	2852
Max	2950	15400	36400	21600	5880	5740	3060	3040	3020	2750	3090	3600
Min	2170	2270	4210	4230	2350	2730	1030	989	1810	1850	2310	1750
1985												
Mean	1248	1601	2145	1262	1178	960	778	559	663	763	392	340
Max	2360	2420	2630	1880	6340	2140	1670	712	949	1320	555	507
Min	737	899	1740	630	631	620	279	460	496	480	212	262
1986												
Mean	485	520	871	1857	20970	12480	3405	1110	1087	1191	833	1593
Max	867	1350	1210	3400	101000	43000	6770	2710	3300	1460	1200	3130
Min	326	364	705	1000	3500	6010	953	585	307	1050	558	752
1987												
Mean	982	597	516	810	1108	1086	438	367	335	176	1060	518
Max	1840	650	601	1030	3360	2710	654	416	391	785	1170	666
Min	380	523	452	628	682	690	320	320	287	67	1010	390
1988												
Mean	461	497	684	1495	1271	626	424	308	309	682	894	641
Max	596	576	926	1910	1570	856	1110	351	354	829	1070	1130
Min	412	428	593	936	675	448	300	272	267	267	779	391

* Source: U.S. Geological Survey (USGS), Water Resources Data - California, water years 1969 through 1988.

APPENDIX II

TABLES CORRESPONDING TO WUA FIGURES
IN TEXT FOR
CHINOOK SALMON

Table II-1.

Chinook salmon fry, juvenile, and spawning total weighted usable area (x 1,000 sq ft) by discharge for the Yuba River study area (Figure 22).

Discharge	Fry	Juvenile	Spawning
100	6119.01	8144.32	1468.01
150	5691.41	8654.69	2405.07
200	5048.92	8651.37	3358.50
250	4439.91	8445.81	4138.33
300	3966.88	8228.76	4799.81
350	3495.10	7946.99	5314.69
400	3134.27	7513.10	5684.37
450	2892.17	6979.46	5889.18
500	2623.78	6577.25	5985.01
600	2164.46	5564.47	6067.15
700	1801.38	4627.56	5979.49
800	1546.31	3949.60	5765.47
900	1384.86	3473.64	5400.60
1000	1277.66	3106.53	5010.50
1250	1126.87	2599.56	4058.54
1500	993.98	2211.39	3094.06
1750	926.80	2009.35	2344.99
2000	870.66	1864.27	1780.38
2500	735.77	1654.39	1281.31

Rev
Develop Habitat duration curves

Discharge	Simpson Lane Bridge	Daguerre Point Dam	Garcia Gravel Pit	Narrows	Total River
100	679.35	2962.28	2441.54	35.84	6119.01
150	654.39	2800.60	2193.53	42.89	5691.41
200	582.07	2496.36	1922.96	47.53	5048.92
250	494.84	2181.13	1711.34	52.60	4439.91
300	434.68	1947.26	1528.30	56.65	3966.88
350	378.23	1721.53	1344.41	50.92	3495.10
400	331.94	1504.38	1252.36	45.59	3134.27
450	289.22	1333.86	1228.39	40.70	2892.17
500	265.38	1181.17	1139.86	37.37	2623.78
600	230.42	910.42	990.85	32.77	2164.46
700	212.63	720.02	841.03	27.70	1801.38
800	196.88	613.90	709.46	26.07	1546.31
900	183.03	561.22	612.94	27.67	1384.86
1000	167.87	538.39	541.38	30.02	1277.66
1250	152.39	445.48	495.70	33.30	1126.87
1500	136.00	371.34	450.15	36.48	993.98
1750	122.94	352.62	411.92	39.33	926.80
2000	114.13	328.20	386.55	41.79	870.66
2500	95.99	265.11	332.04	42.63	735.77

Table II-2b.

Chinook salmon fry total weighted usable area
(x 1,000 sq ft) by discharge for the Yuba River
study area and by habitat type (Figure 23).

Discharge	Low Gradient Riffle	Run/ Glide	Shallow Pool	Deep Pool	Total River
100	632.71	2577.74	1903.54	1005.02	6119.01
150	567.76	2291.27	1876.91	955.48	5691.41
200	482.83	1939.60	1766.05	860.45	5048.92
250	411.43	1658.67	1592.71	777.10	4439.91
300	360.23	1492.41	1390.89	723.36	3966.88
350	311.86	1292.10	1237.80	653.34	3495.10
400	269.23	1180.67	1096.30	588.07	3134.27
450	238.65	1134.43	976.27	542.82	2892.17
500	214.79	1029.75	868.62	510.62	2623.78
600	184.18	855.52	647.45	477.31	2164.46
700	158.83	720.43	480.01	442.12	1801.38
800	130.78	607.31	393.74	414.48	1546.31
900	109.04	534.46	342.73	398.62	1384.86
1000	103.25	475.40	311.97	387.03	1277.66
1250	114.99	420.39	239.38	352.10	1126.87
1500	118.78	355.98	196.20	323.02	993.98
1750	114.15	332.79	185.53	294.33	926.80
2000	103.36	331.21	171.98	264.12	870.66
2500	81.71	297.21	152.58	204.28	735.77

Table II-3a.

Chinook salmon juvenile total weighted usable area
(x 1,000 sq ft) by discharge for the Yuba River
study area and by study reach (Figure 24).

Discharge	Simpson Lane Bridge	Daguerre Point Dam	Garcia Gravel Pit	Narrows	Total River
100	370.61	3411.39	4353.44	8.88	8144.32
150	440.46	3706.58	4498.30	9.36	8654.69
200	457.20	3745.10	4439.22	9.85	8651.37
250	447.54	3651.67	4336.25	10.35	8445.81
300	418.92	3426.06	4372.95	10.83	8228.76
350	386.73	3156.53	4394.45	9.28	7946.99
400	355.17	2907.60	4242.74	7.60	7513.10
450	327.56	2682.54	3962.78	6.57	6979.46
500	302.69	2490.80	3777.48	6.27	6577.25
600	248.49	2153.86	3156.13	5.99	5564.47
700	196.63	1814.06	2610.78	6.10	4627.56
800	158.90	1550.69	2233.87	6.13	3949.60
900	136.35	1340.16	1990.60	6.53	3473.64
1000	122.87	1183.70	1792.90	7.07	3106.53
1250	102.66	1008.76	1480.03	8.11	2599.56
1500	91.73	915.62	1194.18	9.86	2211.39
1750	79.50	868.29	1050.16	11.40	2009.35
2000	81.46	818.37	951.08	13.37	1864.27
2500	83.46	693.96	862.20	14.77	1654.39

Table II-3b.

Chinook salmon juvenile total weighted usable area
(x 1,000 sq ft) by discharge for the Yuba River
study area and by habitat type (Figure 24).

Discharge	Low Gradient Riffle	Run/ Glide	Shallow Pool	Deep Pool	Total River
100	1779.77	4566.25	1456.75	341.55	8144.32
150	1698.95	4929.79	1638.27	387.67	8654.69
200	1523.32	4946.68	1778.78	402.60	8651.37
250	1329.99	4789.79	1908.08	417.95	8445.81
300	1204.05	4674.54	1924.65	425.51	8228.76
350	1074.52	4639.01	1813.31	420.15	7946.99
400	960.11	4451.56	1685.98	415.46	7513.10
450	866.08	4137.55	1558.62	417.21	6979.46
500	778.79	3936.19	1438.46	423.81	6577.25
600	676.87	3229.10	1235.85	422.65	5564.47
700	584.70	2590.97	1031.39	420.49	4627.56
800	524.82	2145.26	866.86	412.67	3949.60
900	470.11	1861.64	733.65	408.25	3473.64
1000	435.12	1646.54	620.82	404.05	3106.53
1250	448.63	1274.58	463.11	413.24	2599.56
1500	392.59	1033.13	386.66	399.01	2211.39
1750	369.50	871.45	352.95	415.45	2009.35
2000	362.32	795.82	319.23	386.89	1864.27
2500	336.76	757.04	240.92	319.67	1654.39

(x 1,000 sq ft) by discharge for the Yuba River study area and by study reach (Figure 25).

Discharge	Simpson Lane Bridge	Daguerre Point Dam	Garcia Gravel Pit	Narrows	Total River
100	29.26	476.11	962.63	0.00	1468.01
150	43.59	882.13	1479.35	0.00	2405.07
200	59.84	1339.70	1958.95	0.00	3358.50
250	78.62	1740.51	2319.20	0.00	4138.33
300	99.30	2107.38	2593.13	0.00	4799.81
350	118.51	2385.06	2811.12	0.00	5314.69
400	132.88	2532.43	3019.06	0.00	5684.37
450	144.64	2584.02	3160.51	0.00	5889.18
500	153.99	2575.97	3255.06	0.00	5985.01
600	168.14	2504.96	3394.05	0.00	6067.15
700	176.34	2353.40	3449.75	0.00	5979.49
800	171.43	2186.72	3407.31	0.00	5765.47
900	157.69	1996.61	3246.30	0.00	5400.60
1000	139.05	1806.48	3064.96	0.00	5010.50
1250	88.79	1372.37	2597.38	0.00	4058.54
1500	55.26	1061.39	1977.42	0.00	3094.06
1750	35.49	863.27	1446.23	0.00	2344.99
2000	21.39	777.26	981.73	0.00	1780.38
2500	9.06	643.93	628.32	0.00	1281.31

Table II-4b.

Chinook salmon spawning total weighted usable area (x 1,000 sq ft) by discharge for the Yuba River study area and by habitat type (Figure 25).

Discharge	Low Gradient Riffle	Run/Glide	Shallow Pool	Deep Pool	Total River
100	463.76	831.67	123.70	48.88	1468.01
150	811.26	1377.92	168.20	47.68	2405.07
200	1130.05	1949.97	229.17	49.32	3358.50
250	1368.69	2415.82	301.39	52.43	4138.33
300	1534.20	2834.20	373.35	58.06	4799.81
350	1630.31	3171.53	448.86	63.99	5314.69
400	1695.63	3396.73	520.78	71.24	5684.37
450	1687.93	3549.50	575.15	76.60	5889.18
500	1601.29	3690.00	611.72	82.01	5985.01
600	1419.61	3903.17	657.73	86.64	6067.15
700	1198.55	3993.55	696.91	90.49	5979.49
800	1047.81	3886.60	736.39	94.68	5765.47
900	928.60	3631.37	741.96	98.67	5400.60
1000	837.98	3357.45	710.85	104.21	5010.50
1250	665.67	2703.10	578.72	111.05	4058.54
1500	535.69	2013.44	426.18	118.75	3094.06
1750	460.57	1416.69	341.63	126.11	2344.99
2000	394.78	951.75	292.79	141.06	1780.38
2500	300.97	593.47	223.03	163.83	1281.31

Table II-5.

Transect unweighted usable area (sq ft/1000 lineal ft of stream)
and total habitat type and reach weighted usable area (sq ft x
1,000) for chinook salmon fry in the lower Yuba River.

SIMPSON LANE STUDY REACH														
TRANSECT	1	2	3	4	5	6	7	8	9	TOTALS				
HABITAT TYPE	LGR	R/G	R/G	SP	SP	DP	DP	DP	DP	LGR	R/G	SP	DP	REACH
DISTANCE (ft)	400	1050	1050	1400	1400	3300	3300	3300	3300	400	2100	2800	13200	18500

Discharge (cfs)

Unweighted Results of PHABSIM (sq ft/1000 ft)

Weighted Usable Area (sq ft) in thousands

50	2925	104521	139323	117888	47746	9684	7313	3937	22606	1.17	256.04	231.89	143.68	632.77
100	15246	122017	149195	100993	38008	12278	9855	6124	30495	6.10	284.77	194.60	193.88	679.35
150	29699	116954	145787	89426	29560	12883	12241	7735	27764	11.88	275.88	166.58	200.05	654.39
200	36750	102502	132335	74471	22268	14009	11063	7055	24042	14.70	246.58	135.43	185.36	582.07
250	37713	81053	114914	62280	17801	14548	10892	5022	18591	15.09	205.76	112.11	161.88	494.84
300	36183	65368	97515	50638	16331	14400	10845	4483	17372	14.47	171.03	93.76	155.43	434.68
350	31887	53934	80525	42562	14827	13396	10995	3992	15239	12.75	141.18	80.34	143.95	378.23
400	28807	43632	65895	36600	11473	13307	11270	3328	13949	11.52	115.00	67.30	138.11	331.94
450	25057	35380	53179	27931	10662	13080	11419	2312	13245	10.02	92.99	54.03	132.18	289.22
500	22416	28711	42706	22478	10338	12804	11057	3961	13234	8.97	74.99	45.94	135.48	265.38
600	18698	20175	28228	17246	9391	11313	10477	5078	13987	7.48	50.82	37.29	134.82	230.42
700	15958	14540	22425	14641	8994	11464	10358	5969	12921	6.38	38.81	33.09	134.35	212.63
800	12658	11204	18597	12099	8478	11495	10228	5924	12269	5.08	31.29	28.81	131.72	196.88
900	8861	8699	14440	10770	8156	11333	10125	5878	11682	3.54	24.30	26.50	128.70	183.03
1000	6083	6578	11493	9700	8060	10980	8258	6016	11597	2.43	18.97	24.86	121.61	167.87
1250	2706	2863	6263	8009	7128	10147	9168	6157	11053	1.08	9.58	21.19	120.53	152.39
1500	2180	1201	3700	6056	5078	8738	9490	6142	10295	0.87	5.15	15.59	114.39	136.00
1750	2614	1443	2878	5256	5083	7692	9368	5714	8464	1.05	4.33	14.48	103.09	122.94
2000	2961	1933	2307	4563	5291	7398	8937	5034	7328	1.18	4.45	13.80	94.70	114.13
2500	3571	1669	2177	3910	5560	6058	8021	3482	5852	1.43	4.04	13.28	77.26	95.99

Revised 11/1/89

Table II-6.

Transect unweighted usable area (sq ft/1000 lineal ft of stream) and total habitat type and reach weighted usable area (sq ft x 1,000) for chinook salmon juveniles in the lower Yuba River.

SIMPSON LANE STUDY REACH														
TRANSECT	1	2	3	4	5	6	7	8	9	TOTALS				
HABITAT TYPE	LGR	R/G	R/G	SP	SP	DP	DP	DP	DP	LGR	R/G	SP	DP	REACH
DISTANCE (ft)	400	1050	1050	1400	1400	3300	3300	3300	3300	400	2100	2800	13200	18500
Discharge (cfs)	Unweighted Results of PHABSIM (sq ft/1000 ft)									Weighted Usable Area (sq ft) in thousands				
50	29115	82942	63710	26808	8498	2092	1833	834	4905	11.65	153.98	49.43	31.57	246.62
100	73737	137483	106560	28629	7608	2487	1908	1102	4849	29.49	258.24	50.73	34.14	370.81
150	115815	185463	129638	28116	6779	2763	2250	1163	4559	48.33	309.88	48.85	35.42	440.46
200	141342	162981	139709	27400	5930	3277	2474	955	4257	58.54	317.82	46.66	36.18	457.20
250	145454	156052	134738	27861	5643	3469	2685	855	4242	58.18	305.33	46.90	37.13	447.54
300	139873	143628	124027	26908	5305	3444	2935	788	3998	55.95	281.03	45.10	36.84	418.92
350	127448	130478	114448	24610	5198	3517	3248	743	3658	50.98	257.17	41.73	36.85	386.73
400	115991	118325	105139	20935	4770	3673	3626	786	3474	46.40	234.64	35.99	38.15	355.17
450	105024	107534	96865	17956	4252	3819	3829	876	3550	42.01	214.62	31.09	39.84	327.58
500	95094	98134	88358	15969	3817	4057	3744	982	3683	38.04	195.82	27.70	41.14	302.69
600	73780	75484	70393	12179	2965	4471	3141	1594	4313	29.51	153.17	21.20	44.61	248.49
700	56243	53030	52071	10091	2529	4809	3070	1667	4426	22.50	110.38	17.67	46.11	196.63
800	42007	36725	37500	8378	2442	4960	3440	1818	4635	16.80	77.94	15.15	49.02	158.90
900	31085	27063	27633	7903	2449	5004	3939	2005	4806	12.43	57.43	14.49	51.99	136.35
1000	23818	21409	21043	7872	2445	5263	4122	2126	4950	9.53	44.57	14.44	54.32	122.87
1250	13458	11748	10865	7403	3308	5213	4265	2707	5555	5.38	23.74	14.99	58.54	102.68
1500	7847	7807	7058	6223	3204	4582	4554	2791	6190	3.14	15.61	13.20	59.79	91.73
1750	6023	5387	5044	4668	2501	4316	5032	2585	5066	2.41	10.95	10.04	56.10	79.50
2000	5436	4915	3830	4143	2461	5372	6111	2626	4332	2.17	9.18	9.25	60.85	81.46
2500	5299	4111	2748	3820	2859	5961	7347	2053	4271	2.12	7.20	9.35	64.79	83.46

C-066907

Table II-7.

Transect unweighted usable area (sq ft/1000 lineal ft of stream)
and total habitat type and reach weighted usable area (sq ft x
1,000) for chinook salmon spawning in the lower Yuba River.

SIMPSON LANE STUDY REACH														
TRANSECT	1	2	3	4	5	6	7	8	9	TOTALS				
HABITAT TYPE	LGR	RVG	RVG	SP	SP	DP	DP	DP	DP	LGR	RVG	SP	DP	REACH
DISTANCE (ft)	400	1050	1050	1400	1400	3300	3300	3300	3300	400	2100	2800	13200	18500

Discharge (cfs)	Unweighted Results of PHABSIM (sq ft/1000 ft)									Weighted Usable Area (sq ft) in thousands				
50	3650	4137	6181	3899	723	1	0	0	0	1.46	10.83	6.47	0.00	18.77
100	15006	6852	9428	3807	589	4	0	0	0	6.00	17.09	8.15	0.01	29.26
150	34049	10622	12338	3689	482	6	0	0	0	13.62	24.11	5.84	0.02	43.59
200	54151	15884	15028	3662	405	9	0	0	0	21.68	32.48	5.69	0.03	59.84
250	75258	22257	18033	4030	355	22	0	0	0	30.10	42.30	6.14	0.07	78.62
300	96383	30678	21351	3970	315	37	0	0	0	38.55	54.83	6.00	0.12	99.30
350	113680	38859	25399	3577	280	51	0	0	0	45.47	67.47	5.40	0.17	118.51
400	126465	43794	29906	3120	258	54	0	0	0	50.59	77.38	4.73	0.18	132.88
450	135709	47390	34478	2783	231	54	0	0	0	54.28	85.96	4.22	0.18	144.64
500	141787	50163	38558	2600	211	55	0	0	0	58.71	93.16	3.94	0.18	153.99
600	144521	53172	48417	2303	175	58	0	0	0	57.81	106.67	3.47	0.19	168.14
700	141835	54517	56105	2197	175	64	0	0	0	58.65	116.15	3.32	0.21	178.34
800	134636	53474	55271	2101	163	68	0	0	0	53.85	114.18	3.17	0.23	171.43
900	121834	50011	50751	1971	161	75	0	0	0	48.65	105.80	2.98	0.25	157.69
1000	105175	45853	43537	1867	172	81	0	0	0	42.07	93.86	2.85	0.27	139.05
1250	61599	31325	27522	1333	173	75	0	0	0	24.84	61.78	2.11	0.25	88.79
1500	35567	21168	17051	244	178	95	0	0	0	14.23	40.13	0.59	0.31	55.28
1750	21816	13953	10664	248	195	114	0	0	0	8.65	25.85	0.62	0.38	35.49
2000	11845	8934	5837	254	257	130	0	0	0	4.74	15.51	0.72	0.43	21.39
2500	2832	4648	1784	239	227	157	0	0	0	1.13	6.75	0.65	0.52	9.06

Revised 11/1/89

Table II-8.

Transect unweighted usable area (sq ft/1000 lineal ft of stream)
and total habitat type and reach weighted usable area (sq ft x
1,000) for chinook salmon fry in the lower Yuba River.

DAGUERRE POINT DAM STUDY REACH												
TRANSECT	1	2	3	4	5	6	7	TOTALS				
HABITAT TYPE	LGR	LGR	R/G	R/G	SP	SP	DP	LGR	R/G	SP	DP	REACH
DISTANCE (ft)	3088	3088	8538	8538	4688	4688	8775	6175	17075	9375	8775	41400
Discharge (cfs)	Unweighted Results of PHABSIM (sq ft/1000 ft)							Weighted Usable Area (sq ft) in thousands				
50	63859	46497	59222	120448	57384	73568	39334	340.78	1534.02	613.89	345.15	2833.84
100	77382	34805	69190	110234	82240	90428	31276	346.43	1531.92	809.47	274.45	2962.28
150	70593	34022	59819	92492	98049	100203	28229	323.05	1300.43	929.40	247.71	2800.60
200	63378	30180	45613	71216	104471	107363	24716	288.91	997.49	993.08	216.88	2496.36
250	56838	23204	38801	49000	100454	109996	22533	247.17	749.64	986.59	197.73	2181.13
300	50996	18998	31612	40218	92818	105092	21657	216.13	613.28	927.80	190.04	1947.26
350	47355	15512	24994	33160	85686	97211	19768	194.13	496.52	857.42	173.46	1721.53
400	42788	13416	19721	28375	77659	87072	16857	173.56	410.64	772.26	147.92	1504.38
450	39619	11373	15307	25238	70420	77455	15610	157.46	346.17	693.24	136.98	1333.86
500	36032	10129	11671	21891	64064	68019	15142	142.54	286.55	619.20	132.87	1181.17
600	30340	8194	8167	15033	47751	49074	15889	118.99	198.08	453.92	139.42	910.42
700	24780	6581	6455	12581	37755	31982	15238	96.84	162.53	326.92	133.72	720.02
800	20504	5310	4555	11098	32143	26175	14489	79.71	133.64	273.39	127.14	613.90
900	17332	3837	3922	10880	28081	22951	14841	65.37	126.38	239.24	130.23	561.22
1000	15362	2723	4118	10709	26232	20459	15619	55.84	126.59	218.89	137.06	538.39
1250	11170	1647	4640	9960	19197	13945	14345	39.58	124.68	155.37	125.88	445.48
1500	7873	1490	5370	8660	16081	10571	11133	28.91	119.79	124.94	97.70	371.34
1750	6110	1350	7724	7015	14654	10276	9899	23.03	125.85	116.87	86.87	352.62
2000	4792	694	8608	7484	12930	9552	7803	16.94	137.39	105.39	68.47	328.20
2500	3600	1040	8969	4952	8792	9616	5200	14.33	118.85	86.29	45.63	265.11

Revised 11/1/89

Table II-9.

Transect unweighted usable area (sq ft/1000 lineal ft of stream)
and total habitat type and reach weighted usable area (sq ft x
1,000) for chinook salmon juveniles in the lower Yuba River.

DAGUERRE POINT DAM STUDY REACH												
TRANSECT	1	2	3	4	5	6	7	TOTALS				
HABITAT TYPE	LGR	LGR	R/G	R/G	SP	SP	DP	LGR	R/G	SP	DP	REACH
DISTANCE (ft)	3088	3088	8538	8538	4688	4688	8775	6175	17075	9375	8775	41400

Discharge (cfs)	Unweighted Results of PHABSIM (sq ft/1000 ft)							Weighted Usable Area (sq ft) in thousands				
50	95019	78721	82151	84236	17550	24513	8038	538.51	1420.61	197.19	70.53	2224.84
100	146403	103079	129517	129828	33474	41159	8754	770.40	2214.29	349.88	76.82	3411.39
150	142685	100659	140314	135657	48887	62067	8974	751.45	2356.24	520.15	78.74	3706.58
200	134688	100116	132531	130012	66709	82218	9148	725.07	2241.59	698.17	80.28	3745.10
250	120994	88418	117668	120719	86068	100877	10628	646.66	2035.34	876.39	93.26	3651.67
300	109961	76997	103934	105753	94025	110958	11108	577.33	1790.30	960.95	97.47	3426.06
350	101070	65413	93179	93080	94569	109170	11054	514.12	1590.28	955.13	97.00	3156.53
400	91854	58447	84146	81093	94883	104979	10906	464.13	1410.81	936.95	95.70	2907.60
450	85899	54859	73573	70502	95443	100795	11145	434.68	1230.11	919.96	97.80	2682.54
500	78937	50738	65530	62761	93413	96939	11697	400.44	1095.35	892.37	102.65	2490.80
600	68375	41371	52819	48708	88653	88172	13581	338.89	866.84	828.96	119.17	2153.88
700	58768	32899	40063	40683	76745	75764	14429	283.07	689.42	714.96	126.62	1814.06
800	51834	26388	30643	36831	67545	61003	14862	241.55	576.10	602.63	130.41	1550.69
900	45069	21535	24264	34173	59637	48216	14807	205.67	498.94	505.61	129.93	1340.16
1000	38971	17638	19816	33627	53217	35767	15434	174.81	456.30	417.15	135.44	1183.70
1250	29136	11696	17184	31748	44323	19075	19109	126.09	417.78	297.21	167.68	1008.76
1500	21488	7952	17854	32182	38048	13512	17753	90.91	427.21	241.71	155.78	915.62
1750	15941	6119	18212	29872	35193	12218	19073	68.12	410.64	222.28	167.36	868.29
2000	11969	4127	21148	26602	31463	12037	17896	49.70	407.70	203.93	157.04	818.37
2500	7203	2952	21892	26700	20728	9224	12229	31.36	414.88	140.41	107.31	693.96

Revised 11/1/89

Table II-10.

Transect unweighted usable area (sq ft/1000 lineal ft of stream) and total habitat type and reach weighted usable area (sq ft x 1,000) for chinook salmon spawning in the lower Yuba River.

DAGUERRE POINT DAM STUDY REACH												
TRANSECT	1	2	3	4	5	6	7	TOTALS				
HABITAT TYPE	LGR	LGR	R/G	R/G	SP	SP	DP	LGR	R/G	SP	DP	REACH
DISTANCE (ft)	3088	3088	8538	8538	4688	4688	8775	6175	17075	9375	8775	41400

Discharge (cfs)	Unweighted Results of PHABSIM (sq ft/1000 ft)							Weighted Usable Area (sq ft) in thousands				
50	3223	5897	4328	10695	4987	3973	2993	28.16	128.27	42.01	26.28	224.70
100	16895	27324	13195	18071	5160	4788	2960	136.55	266.95	46.64	25.97	476.11
150	47890	60948	27825	27083	5849	5810	2538	336.40	468.81	54.66	22.27	882.13
200	84417	78138	45493	42124	7538	7173	2359	501.97	748.07	68.96	20.70	1339.70
250	109087	91711	59118	60066	9282	8464	2248	620.00	1017.59	83.20	19.72	1740.51
300	126042	103637	67029	83027	10795	9823	2313	709.25	1281.18	96.66	20.29	2107.38
350	133037	114025	72788	101933	11927	11315	2442	762.93	1491.75	108.96	21.42	2385.06
400	138023	124239	77716	106974	13004	13108	2652	809.86	1576.88	122.41	23.27	2532.43
450	137293	131500	80853	105181	14777	15475	2713	830.03	1588.36	141.82	23.81	2584.02
500	129283	131145	83907	101659	16874	18042	2702	804.20	1584.37	163.69	23.71	2575.97
600	119216	118223	87265	93077	22124	22528	2583	733.21	1539.76	209.33	22.66	2504.96
700	102148	97446	84914	84697	29989	26702	2638	616.35	1448.14	265.77	23.15	2353.40
800	94162	81097	73495	77704	38093	31982	2971	541.20	1290.94	328.51	26.07	2186.72
900	83925	72423	61898	69695	41410	35825	3213	482.80	1123.54	362.08	28.19	1996.61
1000	76552	63845	53637	61565	41522	34396	3811	433.55	983.60	355.90	33.44	1806.48
1250	64099	48816	39187	41360	36362	26671	4614	348.68	687.71	295.50	40.49	1372.37
1500	53496	35501	26777	31984	32267	18502	5340	274.82	501.70	238.00	46.86	1061.39
1750	45477	24626	17313	28653	30149	12671	6108	216.48	392.46	200.74	53.59	863.27
2000	41182	15339	14829	27219	28946	8898	7555	174.54	359.01	177.41	66.30	777.26
2500	31259	6594	9748	26099	25588	4112	9315	116.89	306.06	139.23	81.74	643.93

Revised 11/1,

C-066911

Table II-11.

Transect unweighted usable area (sq ft/1000 lineal ft of stream)
and total habitat type and reach weighted usable area (sq ft x
1,000) for chinook salmon fry in the lower Yuba River.

GARCIA GRAVEL PIT STUDY REACH

TRANSECT	1	2	3	4	5	6	7	8	9	TOTALS				
HABITAT TYPE	LGR	R/G	R/G	SP	SP	DP	DP	DP	LGR	LGR	R/G	SP	DP	REACH
DISTANCE (ft)	6813	13413	13413	3700	3700	2850	2850	2850	6813	13625	26825	7400	8550	56400

Discharge (cfs)

Unweighted Results of PHABSIM (sq ft/1000 ft)

Weighted Usable Area (sq ft) in thousands

50														
100	19119	5241	51498	118255	124844	82914	43351	49472	22005	280.18	781.05	899.47	500.85	2441.54
150	13777	8129	47174	105019	106041	75539	46518	41040	20397	232.82	714.98	780.92	464.83	2183.53
200	8671	8323	43532	83547	88760	63919	46089	34089	17634	179.22	695.53	637.54	410.68	1922.96
250	6080	9347	43085	62720	70796	54750	44872	28409	15815	149.17	703.27	494.01	364.89	1711.34
300	5034	12408	40385	41572	58248	46728	42792	23194	13994	129.63	708.10	369.33	321.24	1528.30
350	3104	15274	33515	34051	47040	41014	39583	19404	12304	104.98	654.39	300.04	285.01	1344.41
400	1759	20519	28317	31015	38374	35130	37124	17725	10592	84.15	655.03	256.74	256.44	1252.36
450	1499	26709	25128	27693	34199	30208	35091	16443	8947	71.17	695.27	229.00	232.96	1228.39
500	1375	27884	21934	24530	30463	25096	32140	14656	7913	63.28	668.21	203.47	204.89	1139.86
600	1568	28298	16928	18685	23542	20344	28227	11181	6904	57.71	608.61	156.24	170.29	990.85
700	1865	25909	12791	13578	18854	18593	23661	9097	6298	55.60	519.08	120.00	146.35	841.03
800	1488	23153	9828	9167	15574	17705	19847	7903	5264	46.00	442.37	91.54	129.55	709.46
900	1255	20276	8337	7872	12837	15567	18024	5716	4635	40.13	383.79	76.99	112.02	612.94
1000	1160	17284	7307	7735	10701	14038	15453	5016	5443	44.98	329.84	68.22	98.34	541.38
1250	1422	16281	5053	8698	8281	12123	10321	2957	9489	74.34	286.15	62.82	72.39	495.70
1500	858	14127	3099	7988	7057	11733	9955	4435	12204	88.99	231.04	55.66	74.45	450.15
1750	450	11481	3624	9235	5410	12002	8817	2205	12771	90.07	202.61	54.18	65.05	411.92
2000	798	10695	3423	9591	4677	12284	6856	1617	11712	85.23	189.38	52.79	59.16	386.55
2500	1534	10132	2864	9952	4379	7834	4664	1098	8148	65.95	174.32	53.03	38.75	332.04

Revised 11/1/89

Table II-12.

Transect unweighted usable area (sq ft/1000 lineal ft of stream)
and total habitat type and reach weighted usable area (sq ft x
1,000) for chinook salmon juveniles in the lower Yuba River.

GARCIA GRAVEL PIT STUDY REACH														
TRANSECT	1	2	3	4	5	6	7	8	9	TOTALS				
HABITAT TYPE	LGR	R/G	R/G	SP	SP	DP	DP	DP	LGR	LGR	R/G	SP	DP	REACH
DISTANCE (ft)	6813	13413	13413	3700	3700	2850	2850	2850	6813	13625	26825	7400	8550	56400
Discharge (cfs)	Unweighted Results of PHABSIM (sq ft/1000 ft)									Weighted Usable Area (sq ft) in thousands				
50														
100	66903	31928	124317	153252	132193	33761	14720	29311	76921	979.87	2095.71	1056.14	221.71	4353.44
150	59507	36507	132262	153941	135050	41185	18890	32607	72767	901.18	2263.70	1069.27	264.14	4498.30
200	48104	40405	137577	147740	131708	42940	22681	31343	62764	741.72	2387.26	1033.95	276.29	4439.21
250	35259	48653	133940	138708	127449	38782	26764	31718	56499	625.15	2449.12	984.78	277.20	4336.21
300	29845	60858	133225	128200	120073	36987	31177	30230	53933	570.78	2603.20	918.61	280.38	4372.91
350	25342	77681	130443	111652	109012	34918	33337	28945	49429	509.42	2791.58	816.46	277.02	4394.41
400	19663	90560	118649	95983	96730	34229	34186	27728	46328	449.58	2806.11	713.04	274.01	4242.71
450	15691	97185	103596	82972	81235	32968	34271	28548	41468	389.41	2692.82	607.57	272.99	3962.71
500	13130	106841	90358	71391	68712	31993	34658	29402	36822	340.32	2645.02	518.38	273.75	3777.41
600	12494	96091	68607	52844	51398	29600	33783	25346	32781	308.46	2209.09	385.70	252.88	3158.1
700	12082	78105	54437	39253	41494	29024	33587	22187	28889	279.14	1791.20	298.76	241.67	2610.7
800	11749	67054	44123	30490	36828	28314	31282	20090	27363	266.47	1491.22	249.08	227.10	2233.8
900	9505	59131	38183	25389	32328	27301	30031	19786	27483	252.00	1305.27	213.55	219.79	1990.6
1000	9228	52419	32995	23150	27989	25467	30315	16929	27582	250.79	1145.67	189.22	207.23	1792.9
1250	10195	38679	23429	19447	21340	24443	24633	13698	36357	317.16	833.05	150.91	178.91	1480.0
1500	7865	27964	16046	18599	17008	24422	23115	13370	35954	298.54	590.31	131.75	173.58	1194.1
1750	5787	20078	13468	17691	14918	26054	23619	13691	38095	298.97	449.98	120.65	180.59	1050.1
2000	6697	15889	12363	16043	12622	24472	20293	9844	38869	310.44	378.94	106.06	155.64	951.0
2500	9997	14188	10784	13450	11186	22634	17643	6321	34519	303.28	334.95	91.15	132.80	862.2

Revised 11/1/89

C-066913

Table II-13.

Transect unweighted usable area (sq ft/1000 lineal ft of stream)
and total habitat type and reach weighted usable area (sq ft x
1,000) for chinook salmon spawning in the lower Yuba River.

GARCIA GRAVEL PIT STUDY REACH														
TRANSECT	1	2	3	4	5	6	7	8	9	TOTALS				
HABITAT TYPE	LGR	R/G	R/G	SP	SP	DP	DP	DP	LGR	LGR	R/G	SP	DP	REACH
DISTANCE (ft)	6813	13413	13413	3700	3700	2850	2850	2850	6813	13625	26825	7400	8550	56400

Discharge (cfs)	Unweighted Results of PHABSIM (sq ft/1000 ft)									Weighted Usable Area (sq ft) in thousands				
50														
100	273	21287	19541	10251	8912	3137	1429	3469	46874	321.21	547.62	70.90	22.90	962.63
150	555	31893	34088	16236	12872	3152	1508	4250	67146	461.24	885.01	107.70	25.39	1479.35
200	878	40347	46840	24742	17017	3387	1610	5033	88131	606.42	1169.44	154.51	28.59	1958.95
250	1088	45261	55830	34998	22313	3585	1761	6105	104388	718.58	1355.93	212.05	32.63	2319.20
300	1187	48195	63517	43929	29232	3911	1857	7441	114240	788.40	1498.39	270.70	37.64	2593.13
350	1225	51300	68904	54070	36338	4137	1945	8793	119415	821.92	1612.31	334.50	42.40	2811.12
400	1214	55967	73942	63820	42566	4392	2014	10363	121372	835.18	1742.46	393.63	47.79	3019.06
450	1149	61149	78654	69019	46956	4594	2150	11718	116804	803.61	1875.18	429.11	52.62	3160.51
500	1100	68421	81619	69191	50835	5082	2356	12953	107571	740.38	2012.47	444.09	58.11	3255.06
600	1048	82383	85868	66354	53896	6069	2793	13520	91215	628.59	2256.75	444.93	63.79	3394.05
700	829	94650	86462	63332	52295	7315	3308	12930	76310	525.55	2429.26	427.82	67.12	3449.75
800	673	100578	84429	60145	49234	8489	3783	11722	65782	452.75	2481.48	404.70	68.38	3407.31
900	588	97776	81308	58719	45145	8948	4186	10508	57724	397.14	2402.03	376.90	70.23	3246.30
1000	484	92959	77025	53684	41478	11289	4384	9068	52704	362.37	2280.00	352.09	70.51	3064.96
1250	462	83017	62633	41795	34182	14513	4097	6063	42448	292.34	1953.61	281.11	70.32	2597.38
1500	432	69573	40142	22918	27780	16315	4339	4463	35770	246.64	1471.60	187.58	71.58	1977.42
1750	393	46998	27438	15661	22251	17865	4641	2804	34168	235.45	998.38	140.27	72.14	1446.23
2000	365	23941	19095	12133	18856	17832	5564	2686	31267	215.51	577.23	114.68	74.33	981.73
2500	209	10337	10587	8522	13949	17900	8328	2395	26644	182.95	280.65	83.14	81.58	628.32

Revised 11/1/89

Table II-14.

Transect unweighted usable area (sq ft/1000 lineal ft of stream) and total habitat type and reach weighted usable area (sq ft x 1,000) for chinook salmon fry in the lower Yuba River.

NARROWS STUDY REACH								
TRANSECT	1	2	3	4	5	6	TOTALS	
HABITAT TYPE	DP	DP	DP	DP	DP	DP	DP	REACH
DISTANCE (ft)	1463	1463	1463	1463	1463	1463	8775	8775

Discharge (cfs)	Unweighted Results of PHABSIM (sq ft/1000 ft)						WUA (thousands)	
50								
100	0	176	2716	4915	13756	2932	35.84	35.84
150	0	280	2624	6656	15691	4065	42.89	42.89
200	0	353	2780	8425	16106	4824	47.53	47.53
250	0	428	2824	9747	18389	4564	52.60	52.60
300	0	508	2745	10604	21158	3706	56.65	56.65
350	4	593	1730	10173	19175	3133	50.92	50.92
400	16	681	1778	9277	17158	2255	45.59	45.59
450	65	772	1905	8544	15384	1150	40.70	40.70
500	126	844	1870	7815	13810	1082	37.37	37.37
600	212	1064	1919	6676	11067	1461	32.77	32.77
700	315	1263	1736	5874	7973	1773	27.70	27.70
800	432	1407	1634	3330	8937	2078	26.07	26.07
900	542	1545	1492	3427	9491	2419	27.67	27.67
1000	621	1677	1877	3647	9908	2789	30.02	30.02
1250	829	1729	2688	4350	9822	3343	33.30	33.30
1500	1055	1630	2994	4852	10584	3823	36.48	36.48
1750	1297	1521	3264	4864	11688	4248	39.33	39.33
2000	1558	1399	3400	4873	12697	4636	41.79	41.79
2500	2061	522	2574	5541	13143	5301	42.63	42.63

Transect unweighted usable area (sq ft/1000 lineal ft of stream)
and total habitat type and reach weighted usable area (sq ft x
1,000) for chinook salmon juveniles in the lower Yuba River.

NARROWS STUDY REACH

TRANSECT	1	2	3	4	5	6	TOTALS	
HABITAT TYPE	DP	DP	DP	DP	DP	DP	DP	REACH
DISTANCE (ft)	1463	1463	1463	1463	1463	1463	8775	8775

Discharge (cfs)	Unweighted Results of PHABSIM (sq ft/1000 ft)						WUA (thousands)	
50								
100	0	90	824	1265	3224	671	8.88	8.88
150	0	112	740	1504	3270	772	9.36	9.36
200	0	131	557	1732	3572	740	9.85	9.85
250	3	149	519	1954	3812	639	10.35	10.35
300	8	165	442	2155	4091	542	10.83	10.83
350	16	183	394	1827	3468	456	9.28	9.28
400	27	200	364	1502	2718	382	7.60	7.60
450	41	217	374	1279	2259	324	6.57	6.57
500	55	228	346	1213	2171	275	6.27	6.27
600	132	267	292	1108	2001	296	5.99	5.99
700	159	292	309	858	1949	499	6.10	6.10
800	181	284	349	851	1931	597	6.13	6.13
900	203	274	372	910	2095	612	6.53	6.53
1000	224	257	400	981	2252	715	7.07	7.07
1250	275	225	533	1156	2378	979	8.11	8.11
1500	325	216	624	1325	2991	1260	9.86	9.86
1750	375	203	744	1298	3618	1557	11.40	11.40
2000	425	185	868	1535	4256	1871	13.37	13.37
2500	487	119	505	2048	4404	2533	14.77	14.77

Table II-16.
 Transect unweighted usable area (sq ft/1000 lineal ft of stream)
 and total habitat type and reach weighted usable area (sq ft x
 1,000) for chinook salmon spawning in the lower Yuba River.

NARROWS STUDY REACH							
TRANSECT	1	2	3	4	5	6	TOTALS
HABITAT TYPE	DP	DP	DP	DP	DP	DP	GP
DISTANCE (ft)	1463	1463	1463	1463	1463	1463	8775

Discharge (cfs) Unweighted Results of PHABSIM (sq ft/1000 ft)

50	0	0	0	0	0	0	0.00
100	0	0	0	0	0	0	0.00
150	0	0	0	0	0	0	0.00
200	0	0	0	0	0	0	0.00
250	0	0	0	0	0	0	0.00
300	0	0	0	0	0	0	0.00
350	0	0	0	0	0	0	0.00
400	0	0	0	0	0	0	0.00
450	0	0	0	0	0	0	0.00
500	0	0	0	0	0	0	0.00
600	0	0	0	0	0	0	0.00
700	0	0	0	0	0	0	0.00
800	0	0	0	0	0	0	0.00
900	0	0	0	0	0	0	0.00
1000	0	0	0	0	0	0	0.00
1250	0	0	0	0	0	0	0.00
1500	0	0	0	0	0	0	0.00
1750	0	0	0	0	0	0	0.00
2000	0	0	0	0	0	0	0.00
2500	0	0	0	0	0	0	0.00

WUA (thousands)

Table II-17.

River total weighted usable area (sq ft x 1,000) by habitat type for chinook salmon fry in the lower Yuba River.

HABITAT TYPE	LGR	R/G	SP	DP	RIVER
DISTANCE (ft)	20200	46000	19575	39300	125075

Discharge (cfs)

Weighted Usable Area (sq ft) in thousands

50					
100	632.71	2577.74	1903.54	1005.02	6119.01
150	567.76	2291.27	1876.91	955.48	5691.41
200	482.83	1939.60	1766.05	860.45	5048.92
250	411.43	1658.67	1592.71	777.10	4439.91
300	360.23	1492.41	1390.89	723.36	3966.88
350	311.86	1292.10	1237.80	653.34	3495.10
400	269.23	1180.67	1096.30	588.07	3134.27
450	238.65	1134.43	976.27	542.82	2892.17
500	214.79	1029.75	868.62	510.62	2623.78
600	184.18	855.52	647.45	477.31	2164.46
700	158.83	720.43	480.01	442.12	1801.38
800	130.78	607.31	393.74	414.48	1546.31
900	109.04	534.46	342.73	398.62	1384.86
1000	103.25	475.40	311.97	387.03	1277.66
1250	114.99	420.39	239.38	352.10	1126.87
1500	118.78	355.98	196.20	323.02	993.98
1750	114.15	332.79	185.53	294.33	926.80
2000	103.36	331.21	171.98	264.12	870.66
2500	81.71	297.21	152.58	204.28	735.77

C-066918

Revised 11/1/89

Table II-18.

River total weighted usable area (sq ft x 1,000) by habitat type for chinook salmon juveniles in the lower Yuba River.

HABITAT TYPE	LGR	R/G	SP	DP	RIVER
DISTANCE (ft)	20200	46000	19575	39300	125075

Discharge (cfs)

Weighted Usable Area (sq ft) in thousands

50					
100	1779.77	4566.25	1456.75	341.55	8144.32
150	1698.95	4929.79	1638.27	387.67	8654.69
200	1523.32	4946.68	1778.78	402.60	8651.37
250	1329.99	4789.79	1908.08	417.95	8445.81
300	1204.05	4674.54	1924.65	425.51	8228.76
350	1074.52	4639.01	1813.31	420.15	7946.99
400	960.11	4451.56	1685.98	415.46	7513.10
450	866.08	4137.55	1558.62	417.21	6979.46
500	778.79	3936.19	1438.46	423.81	6577.25
600	676.87	3229.10	1235.85	422.65	5564.47
700	584.70	2590.97	1031.39	420.49	4627.56
800	524.82	2145.26	866.86	412.67	3949.60
900	470.11	1861.64	733.65	408.25	3473.64
1000	435.12	1646.54	620.82	404.05	3106.53
1250	448.63	1274.58	463.11	413.24	2599.56
1500	392.59	1033.13	386.66	399.01	2211.39
1750	369.50	871.45	352.95	415.45	2009.35
2000	362.32	795.82	319.23	386.89	1864.27
2500	336.76	757.04	240.92	319.67	1654.39

Table II-19.

River total weighted usable area (sq ft x 1,000) by habitat type for chinook salmon spawning in the lower Yuba River.

HABITAT TYPE	LGR	R/G	SP	DP	RIVER
DISTANCE (ft)	20200	46000	19575	39300	125075

Discharge (cfs)

Weighted Usable Area (sq ft) in thousands

50					
100	463.76	831.67	123.70	48.88	1468.01
150	811.26	1377.92	168.20	47.68	2405.07
200	1130.05	1949.97	229.17	49.32	3358.50
250	1368.69	2415.82	301.39	52.43	4138.33
300	1534.20	2834.20	373.35	58.06	4799.81
350	1630.31	3171.53	448.88	63.99	5314.69
400	1695.63	3396.73	520.78	71.24	5684.37
450	1687.93	3549.50	575.15	76.60	5889.18
500	1601.29	3690.00	611.72	82.01	5985.01
600	1419.61	3903.17	657.73	86.64	6067.15
700	1198.55	3993.55	696.91	90.49	5979.49
800	1047.81	3886.60	736.39	94.68	5765.47
900	928.60	3631.37	741.96	98.67	5400.60
1000	837.98	3357.45	710.85	104.21	5010.50
1250	665.67	2703.10	578.72	111.05	4058.54
1500	535.69	2013.44	426.18	118.75	3094.06
1750	460.57	1416.69	341.63	126.11	2344.99
2000	394.78	951.75	292.79	141.06	1780.38
2500	300.97	593.47	223.03	163.83	1281.31

Revised 11/1/89

APPENDIX III

TABLES CORRESPONDING TO WUA FIGURES
IN TEXT FOR
STEELHEAD TROUT

Table III-1.
Steelhead fry, juvenile, and spawning
total weighted usable area (sq ft x 1000)
by discharge for the Yuba River study area
(Figure 26).

Discharge	Fry	Juvenile	Spawning
100	7595	7994	474
150	7619	9322	972
200	7505	9865	1543
250	7109	9967	2093
300	6742	9920	2599
350	6462	9786	3025
400	5944	9547	3390
450	5463	9219	3693
500	5045	8821	3914
600	4417	7987	4217
700	3897	7105	4355
800	3499	6287	4266
900	3163	5518	3976
1000	2868	4821	3513
1250	2489	3611	2294
1500	2240	3013	1437
1750	2083	2636	991
2000	1981	2423	841
2500	1842	2153	778

Table III-2a.
Steelhead fry total weighted usable area
(sq ft x 1000) by discharge for the Yuba River
study area and by study reach (Figure 27).

Discharge	Simpson Lane	Daguerre Pt. Dam	Garcia Gravel Pit	Narrows	Total River
50					
100	424	3230	3919	22	7595
150	496	3305	3790	28	7619
200	570	3230	3669	36	7505
250	624	2979	3458	48	7109
300	641	2697	3339	65	6742
350	645	2384	3352	81	6462
400	642	2091	3119	92	5944
450	636	1869	2857	101	5463
500	627	1682	2626	110	5045
600	605	1437	2246	129	4417
700	576	1298	1878	145	3897
800	544	1182	1616	157	3499
900	517	1133	1349	164	3163
1000	490	1072	1139	167	2868
1250	430	938	951	170	2489
1500	392	824	854	170	2240
1750	359	749	806	169	2083
2000	315	702	797	167	1981
2500	231	688	767	156	1842

Table III-2b.
Steelhead fry total weighted usable area
(sq ft x 1000) by discharge for the Yuba River
study area and by habitat type (Figure 27).

Discharge	Low Gradient Riffle	Run/ Glide	Shallow Pool	Deep Pool	Total River
50					
100	1658	4022	1421	494	7595
150	1443	3935	1604	637	7619
200	1222	3914	1582	787	7505
250	1006	3724	1495	884	7109
300	831	3583	1382	948	6742
350	702	3529	1237	995	6462
400	617	3214	1104	1008	5944
450	550	2897	1000	1014	5463
500	509	2608	911	1018	5045
600	462	2146	773	1036	4417
700	417	1789	671	1020	3897
800	457	1434	604	1005	3499
900	454	1164	549	997	3163
1000	417	985	500	968	2868
1250	357	839	410	883	2489
1500	354	736	355	795	2240
1750	332	719	303	729	2083
2000	304	729	274	674	1981
2500	251	778	237	576	1842

Table III-3a.
Steelhead juvenile total weighted usable area
(sq ft x 1000) by discharge for the Yuba River
study area and by study reach (Figure 28).

Discharge	Simpson Lane	Daguerre Pt. Dam	Garcia Gravel Pit	Narrows	Total River
50					
100	382	3374	4238	0	7994
150	525	4072	4725	0	9322
200	588	4333	4944	0	9865
250	616	4383	4968	0	9967
300	630	4302	4988	0	9920
350	633	4137	5015	1	9786
400	630	3915	5001	1	9547
450	619	3678	4920	2	9219
500	607	3412	4800	2	8821
600	568	2975	4440	4	7987
700	526	2619	3954	6	7105
800	477	2317	3484	9	6287
900	434	2096	2977	11	5518
1000	395	1883	2530	13	4821
1250	310	1526	1757	18	3611
1500	251	1280	1464	18	3013
1750	222	1107	1289	18	2636
2000	199	1009	1196	19	2423
2500	168	879	1079	27	2153

Table III-3b.
Steelhead juvenile total weighted usable area
(sq ft x 1000) by discharge for the Yuba River
study area and by habitat type (Figure 28).

Discharge	Low Gradient Riffle	Run/ Glide	Shallow Pool	Deep Pool	Total River
50					
100	1568	4099	1604	723	7994
150	1747	4612	2082	882	9322
200	1734	4925	2256	950	9865
250	1576	5099	2328	965	9967
300	1384	5221	2349	966	9920
350	1225	5263	2321	978	9786
400	1089	5225	2266	967	9547
450	972	5102	2191	954	9219
500	885	4891	2105	940	8821
600	778	4369	1925	915	7987
700	699	3781	1746	880	7105
800	666	3197	1579	845	6287
900	623	2681	1402	812	5518
1000	578	2219	1247	777	4821
1250	499	1485	939	689	3611
1500	455	1217	723	617	3013
1750	429	1067	565	575	2636
2000	415	1005	474	530	2423
2500	392	925	365	470	2153

Table III-4a.
Steelhead spawning total weighted usable area
(sq ft x 1000) by discharge for the Yuba River
study area and by study reach (Figure 29).

Discharge	Simpson Lane	Daguerre Pt. Dam	Garcia Gravel Pit	Narrows	Total River
50					
100	1	44	429	0	474
150	2	207	763	0	972
200	6	454	1083	0	1543
250	11	702	1380	0	2093
300	18	912	1669	0	2599
350	26	1061	1938	0	3025
400	35	1162	2193	0	3390
450	44	1207	2442	0	3693
500	53	1216	2645	0	3914
600	65	1186	2966	0	4217
700	71	1127	3157	0	4355
800	69	1053	3144	0	4266
900	62	970	2944	0	3976
1000	53	872	2588	0	3513
1250	31	676	1587	0	2294
1500	18	520	899	0	1437
1750	11	441	539	0	991
2000	7	411	423	0	841
2500	3	403	372	0	778

Table III-4b.
Steelhead spawning total weighted usable area
(sq ft x 1000) by discharge for the Yuba River
study area and by habitat type (Figure 29).

Discharge	Low Gradient Riffle	Run/ Glide	Shallow Pool	Deep Pool	Total River
50					
100	73	401	0	0	474
150	147	822	3	0	972
200	213	1311	19	0	1543
250	258	1772	63	0	2093
300	280	2175	143	0	2599
350	281	2511	232	1	3025
400	266	2802	321	2	3390
450	245	3057	386	3	3693
500	221	3260	429	4	3914
600	178	3548	482	9	4217
700	148	3682	511	15	4355
800	133	3589	523	23	4266
900	128	3301	516	31	3976
1000	125	2865	486	37	3513
1250	116	1750	376	51	2294
1500	110	994	272	62	1437
1750	116	599	206	70	991
2000	148	439	176	78	841
2500	166	371	142	98	778

Table III-5.
Transect weighted usable area (WUA) in square feet per 1,000 lineal feet of
stream for steelhead trout fry in the lower Yuba River.

TRANSECT HABITAT TYPE DISTANCE	NARROWS STUDY REACH						WUA in square feet x 1000 REACH
	1 DP	2 DP	3 DP	4 DP	5 DP	6 DP	
	1463	1463	1463	1463	1463	1463	8778
FLOW (cfs)							
50							
100	1340	1101	2354	3048	3767	3469	22
150	1430	1290	2322	4008	4871	5236	28
200	1521	1480	2439	5119	6234	7501	36
250	1617	1754	2608	7277	7690	11972	48
300	1721	2120	2905	10305	10715	16985	65
350	1821	2539	3211	12896	14162	20644	81
400	1919	2980	3531	14691	17164	22798	92
450	2015	3595	3942	16209	18969	24501	101
500	2110	4453	4648	17951	20524	25676	110
600	2298	6632	6945	21700	23341	26952	129
700	2524	8842	9627	24561	26199	27551	145
800	2885	10317	11637	25861	29218	27677	157
900	3260	11347	12796	26003	31499	27023	164
1000	3641	11861	13679	25980	33027	25741	167
1250	4657	12594	15177	26661	33566	23392	170
1500	6438	12690	16357	25993	33309	21406	170
1750	9191	12358	17085	24688	32428	19939	169
2000	12036	11681	17003	22994	31361	18815	167
2500	15053	10327	15805	20570	29151	15992	156

Table III-6.
Transect weighted usable area (WUA) in square feet per 1,000 lineal feet of
stream for steelhead trout fry in the lower Yuba River.

TRANSECT HABITAT TYPE DISTANCE	GARCIA GRAVEL PIT STUDY REACH									WUA in square feet x 1000				
	1 LGR	2 R/G	3 R/G	4 SP	5 SP	6 DP	7 DP	8 DP	9 LGR	LGR+	R/G	SP	DP	REACH
	6813	13413	13413	3700	3700	2850	2850	2850	6813	13626	26826	7400	8550	56400
FLOW (cfs)														
50														
100	56401	35162	106413	128180	117001	34368	19175	27349	73078	882	1899	907	231	3919
150	46040	38873	115696	100576	96168	38119	28032	29036	59330	718	2073	728	271	3790
200	35369	48109	117488	83956	77013	38516	33998	28356	47559	565	2221	596	287	3669
250	26357	64075	101944	73679	65853	37173	34884	27025	37262	433	2227	516	282	3458
300	19389	79749	90064	62528	57542	35480	34471	26893	30727	341	2278	444	276	3339
350	15186	98980	80600	52993	50962	34285	34005	27297	26832	286	2409	385	272	3352
400	14688	95297	72497	45820	46061	33196	32785	25195	24594	268	2251	340	260	3119
450	13052	88037	64827	39874	41927	31921	32480	23232	24159	254	2050	303	250	2857
500	12537	80709	57973	34707	38600	31537	32202	21959	24355	251	1860	271	244	2626
600	10968	68955	45272	28460	32388	31405	29762	19802	26858	258	1532	225	231	2246
700	10661	57531	34026	23520	27310	31052	27309	16815	25733	248	1228	188	214	1878
800	12824	45860	24397	19749	22778	30103	25747	14649	33626	316	942	157	201	1616
900	13492	33806	17419	18178	18611	28912	23024	14222	36017	337	687	136	189	1349
1000	13902	25444	13458	16744	15271	27521	20852	14613	32897	319	522	118	180	1139
1250	9349	17463	11761	14349	12530	22757	21997	15269	33029	289	392	99	171	951
1500	8551	13430	10138	13432	11427	20632	19235	10648	35721	302	316	92	144	854
1750	8202	12135	9758	13851	11147	18922	18015	9591	33968	287	294	92	133	806
2000	8371	11276	11116	14210	10945	17570	19258	9785	31380	271	300	93	133	797
2500	7970	11179	13208	12148	11937	14026	21241	7455	25587	229	327	89	122	767

Table III-7.

Transect weighted usable area (WUA) in square feet per 1,000 lineal feet of stream for steelhead trout fry in the lower Yuba River.

TRANSECT HABITAT TYPE DISTANCE	DAGUERRE POINT DAM STUDY REACH							WUA in square feet x 1000				
	1 LGR 3088	2 LGR 3088	3 R/G 8538	4 R/G 8538	5 SP 4688	6 SP 4688	7 DP 8775	LGR+ 6176	R/G 17076	SP 9376	DP 8775	REACH 41403
FLOW (cfs)												
50	136785	90016	120961	108709	18054	22684	5523	700	1961	191	48	2901
100	134896	103043	116782	101201	42762	56942	19023	735	1861	467	167	3230
150	127075	92300	105510	83725	83025	86461	24714	677	1616	795	217	3305
200	115844	82375	99826	72891	91479	99886	28078	612	1475	897	246	3230
250	100482	71650	89652	63584	90626	99110	28418	532	1308	889	249	2979
300	84006	62578	76982	56931	86707	94116	28923	453	1143	848	254	2697
350	70241	54150	62708	52177	77749	84819	29324	384	981	762	257	2384
400	58508	45902	51257	47518	70073	74071	28416	322	843	676	249	2091
450	50093	38917	43411	43463	64902	65493	27470	275	742	611	241	1869
500	43009	34554	36240	40673	59986	58816	26125	240	657	557	229	1682
600	33516	28585	27902	35774	53677	46455	26501	192	544	469	233	1437
700	27542	24205	24366	34983	49627	36468	26008	160	507	404	228	1298
800	23865	19498	21582	31058	48967	29436	26392	134	449	368	232	1182
900	21023	15210	22507	29493	46021	25504	27534	112	444	335	242	1133
1000	18326	12202	21518	29773	42784	22873	26496	94	438	308	233	1072
1250	13777	7719	23572	26977	36311	17047	21679	66	432	250	190	938
1500	9067	7220	21345	26594	33353	12370	17139	50	409	214	150	824
1750	6805	7088	22320	26649	26773	10280	13080	43	416	174	115	749
2000	5949	4227	23925	25503	22452	10081	10996	31	422	153	96	702
2500	3127	3592	22689	29399	17950	9596	10694	21	445	129	94	688

Table III-8.
Transect weighted usable area (WUA) in square feet per 1,000 lineal feet of
stream for steelhead trout fry in the lower Yuba River.

TRANSECT HABITAT TYPE DISTANCE	SIMPSON LANE STUDY REACH									WUA in square feet x 1000					
	1	2	3	4	5	6	7	8	9	LGR+	R/G	SP	DP	REACH	RIVER
	LGR	R/G	R/G	SP	SP	DP	DP	DP	DP						
	400	1050	1050	1400	1400	3300	3300	3300	3300	400	2100	2800	13200	18500	125075
FLOW (cfs)															
50	56783	117427	76439	10508	4955	3905	3666	2969	3321	23	204	22	46	294	
100	102710	137892	111316	22726	10519	6766	6232	4316	5215	41	262	47	74	424	7595
150	119046	123162	111313	35122	22855	11456	10015	6802	8452	48	246	81	121	496	7619
200	113407	110075	97783	36039	27393	21345	18885	10457	15231	45	218	89	218	570	7505
250	102444	94063	85999	34288	29463	28993	27158	16883	19357	41	189	89	305	624	7109
300	91047	81696	73030	32733	31506	31700	30213	23611	21325	36	162	90	353	641	6742
350	78292	71128	60845	31016	33107	33389	32051	28006	23257	31	139	90	385	645	6462
400	66627	61713	52276	29656	33672	34629	33233	29985	25602	27	120	89	407	642	5944
450	55283	54167	46158	28634	32817	35401	34093	30931	27576	22	105	86	422	636	5463
500	45764	46165	40659	27877	31186	35974	34776	31712	29244	18	91	83	435	627	5045
600	32500	34443	31974	27446	28664	36335	35121	32988	29892	13	70	79	443	605	4417
700	24041	26237	25622	28625	27732	34924	33243	33840	29134	10	54	79	433	576	3897
800	17277	19611	21024	29913	26798	32979	30771	33247	28861	7	43	79	415	544	3499
900	12086	14405	17226	29571	25915	31423	29108	31894	29306	5	33	78	402	517	3163
1000	8862	10371	13674	27760	24565	29814	27607	30560	29597	4	25	73	388	490	2868
1250	5393	5648	8263	22580	20738	26785	25928	27768	26333	2	15	61	352	430	2489
1500	4529	4790	5557	17156	17386	25430	26805	25231	22821	2	11	48	331	392	2240
1750	4413	4348	3857	12790	13780	24665	26035	22913	20819	2	9	37	312	359	2083
2000	4423	3438	3131	9605	10504	21878	22345	21031	18936	2	7	28	278	315	1981
2500	4280	3073	2918	6746	6676	14887	15391	17095	14379	2	6	19	204	231	1842

Table III-9.

Transect weighted usable area (WUA) in square feet per 1,000 lineal feet of stream for steelhead trout juveniles in the lower Yuba River.

TRANSECT HABITAT TYPE DISTANCE	NARROWS STUDY REACH						WUA in square feet x 1000 REACH
	1 DP	2 DP	3 DP	4 DP	5 DP	6 DP	
	1463	1463	1463	1463	1463	1463	8778
FLOW (cfs)							
50							
100	0	0	0	0	0	0	0
150	0	0	0	0	0	0	0
200	0	0	0	0	0	74	0
250	0	0	0	2	0	132	0
300	0	0	0	48	47	133	0
350	0	0	0	100	159	153	1
400	0	0	0	134	402	282	1
450	0	0	0	171	617	370	2
500	0	0	0	238	780	427	2
600	0	0	0	585	1461	576	4
700	0	0	0	961	2217	1100	6
800	0	0	17	1192	3098	1533	9
900	0	0	60	1622	3809	1736	11
1000	0	0	99	2423	4887	1625	13
1250	0	0	170	4332	6124	1544	18
1500	0	0	182	4500	5885	1611	18
1750	0	0	284	4229	5418	2100	18
2000	0	5	381	4181	5171	3273	19
2500	0	129	518	4753	8060	4705	27

Table III-10.
Transect weighted usable area (WUA) in square feet per 1,000 lineal feet of
stream for steelhead trout juveniles in the lower Yuba River.

TRANSECT HABITAT TYPE DISTANCE	GARCIA GRAVEL PIT STUDY REACH									WUA in square feet x 1000				
	1	2	3	4	5	6	7	8	9	LGR+	R/G	SP	DP	REACH
	LGR	R/G	R/G	SP	SP	DP	DP	DP	LGR					
	6813	13413	13413	3700	3700	2850	2850	2850	6813	13626	26826	7400	8550	56400
FLOW (cfs)														
50														
100	58293	32065	107585	136762	132242	79928	21027	54137	77872	928	1873	995	442	4238
150	62149	37201	124613	145726	139815	84198	36180	56110	83996	996	2170	1056	503	4725
200	56944	44006	135650	148689	141215	83562	45044	55608	80426	936	2410	1073	525	4944
250	47043	50884	141311	149663	139674	81776	48403	54613	69197	792	2578	1071	527	4968
300	37567	62746	143319	146717	136382	79717	49776	53196	58647	656	2764	1047	521	4988
350	31480	75104	142665	142017	131647	77774	50766	51988	51626	566	2921	1013	515	5015
400	26225	86565	139165	136226	125601	75975	50233	50212	47335	501	3028	969	503	5001
450	19684	96498	133301	127099	119181	73920	50229	47844	44499	437	3082	911	490	4920
500	15840	103568	125456	116957	112696	72342	50212	45393	42758	399	3072	850	479	4800
600	12315	109166	106715	98150	99270	68471	49695	39306	41205	365	2896	730	449	4440
700	11009	103495	88505	80788	86249	64319	48393	34116	39373	343	2575	618	418	3954
800	11725	95205	71035	65246	74175	59662	47363	29370	39449	349	2230	516	389	3484
900	11739	84499	54431	50327	61484	54763	45521	25872	38163	340	1863	414	360	2977
1000	11442	72658	41257	39250	52921	50100	43329	22920	36895	329	1528	341	332	2530
1250	9718	44130	26052	26839	35136	39605	37734	17311	36745	317	941	229	270	1757
1500	9145	34988	20222	22094	27019	32149	32675	14886	36923	314	741	182	227	1464
1750	6526	29025	17531	20098	21795	28562	28580	12619	39147	311	624	155	199	1289
2000	5999	26050	15859	19491	18557	25827	24741	11324	40556	317	562	141	176	1196
2500	9245	23115	12757	17160	14828	22998	21366	8454	39008	329	481	118	151	1079

-159-

C-066931

Table III-11.
Transect weighted usable area (WUA) in square feet per 1,000 lineal feet of
stream for steelhead trout juveniles in the lower Yuba River.

TRANSECT HABITAT TYPE DISTANCE	DAGUERRE POINT DAM STUDY REACH							WUA in square feet x 1000				
	1	2	3	4	5	6	7	LGR+	R/G	SP	DP	REACH
	LGR	LGR	R/G	R/G	SP	SP	DP					
	3088	3088	8538	8538	4688	4688	8775	6176	17076	9376	8775	41403
FLOW (cfs)												
50	71054	61355	70866	103036	19535	24076	5175	409	1485	204	45	2144
100	111730	87196	104545	123899	47621	65753	31711	614	1950	531	278	3374
150	130257	100053	121749	128194	89899	93312	41943	711	2134	859	368	4072
200	137467	104486	128814	128341	103881	108142	45213	747	2196	994	397	4333
250	135312	99900	129936	127221	110378	118371	44312	726	2196	1072	389	4383
300	125014	91343	124766	124970	115012	124442	43159	668	2132	1123	379	4302
350	115512	78095	116851	120101	116597	125913	43188	598	2023	1137	379	4137
400	103790	67457	108659	112568	116193	125719	41420	529	1889	1134	363	3915
450	94321	60675	97053	104837	115044	125302	39806	479	1724	1127	349	3678
500	85946	54361	82300	97625	112974	123816	37919	433	1536	1110	333	3412
600	73036	46394	61181	81850	108866	118119	36570	369	1221	1064	321	2975
700	63353	39884	48353	67284	105271	109809	34709	319	987	1008	305	2619
800	58198	34744	39532	52242	102415	100846	33398	287	784	953	293	2317
900	53866	29933	33403	44738	97163	91373	32619	259	667	884	286	2096
1000	49302	24584	27804	38634	91989	81143	31459	228	567	812	276	1883
1250	41194	13934	21834	33204	78187	57627	28342	170	470	637	249	1526
1500	33663	9416	18136	32483	64504	39638	25792	133	432	488	226	1280
1750	27969	8279	16833	31727	53527	25489	23950	112	415	370	210	1107
2000	23534	6746	17742	31639	44403	20275	21731	94	422	303	191	1009
2500	15260	4310	19837	30557	31674	16556	18437	60	430	226	162	879

Table III-12.

Transect weighted usable area (WUA) in square feet per 1,000 lineal feet of stream for steelhead trout juveniles in the lower Yuba River.

TRANSECT HABITAT TYPE DISTANCE	SIMPSON LANE STUDY REACH									WUA in square feet x 1000					
	1	2	3	4	5	6	7	8	9	LGR+	R/G	SP	DP	REACH	RIVER
	LGR	R/G	R/G	SP	SP	DP	DP	DP	DP						
	400	1050	1050	1400	1400	3300	3300	3300	3300	400	2100	2800	13200	18500	125075
FLOW (cfs)															
50	27499	93237	90632	5682	753	0	0	0	0	11	193	9	0	213	
100	64414	130459	132730	42645	12302	658	233	0	1	26	276	77	3	382	7994
150	100569	145263	147689	81464	37318	2118	1048	63	177	40	308	166	11	525	9322
200	126995	152696	151448	89454	46154	5047	2008	152	1217	51	319	190	28	588	9865
250	143253	156385	152823	87546	44505	8297	3404	184	2861	57	325	185	49	616	9967
300	151208	157197	152042	84886	42886	9482	5217	455	4779	60	325	179	66	630	9920
350	151120	155051	148466	81202	40993	10306	6546	798	7392	60	319	171	83	633	9786
400	148309	149114	144594	77192	38998	10860	6887	1109	11299	59	308	163	100	630	9547
450	140738	142150	139998	73197	36282	11215	7074	1398	14593	56	296	153	113	619	9219
500	131885	134906	134568	69710	33931	11106	7887	1791	17427	53	283	145	126	607	8821
600	110775	118380	121931	63588	29482	11684	9693	3029	18230	44	252	130	141	568	7987
700	91365	100210	108111	59394	26231	13336	10274	4069	18026	37	219	120	151	526	7105
800	75425	80213	93993	55584	23451	13868	9830	4192	18695	30	183	111	154	477	6287
900	61518	62850	80629	53135	21118	13269	9762	4224	19774	25	151	104	155	434	5518
1000	50758	49866	68294	48747	18915	12558	9581	4808	20236	20	124	95	156	395	4821
1250	31291	28033	42231	37529	14345	11328	8785	6949	18860	13	74	73	152	310	3611
1500	19782	17070	24583	27894	10128	11581	10236	6280	16115	8	44	53	146	251	3013
1750	14311	10579	16067	20863	7730	12178	12205	5870	14585	6	28	40	148	222	2636
2000	10848	8065	11801	15394	5947	11855	12328	5838	13736	4	21	30	144	199	2423
2500	8118	5388	7803	10085	4726	10423	11318	5897	11789	3	14	21	130	168	2153

-161-

C-066933

Table III-13.
 Transect weighted usable area (WUA) in square feet per 1,000 lineal feet of
 stream for steelhead trout spawning in the lower Yuba River.

NARROWS STUDY REACH							
TRANSECT	1	2	3	4	5	6	WUA in square feet x 1000
HABITAT TYPE	DP	DP	DP	DP	DP	DP	
DISTANCE	1463	1463	1463	1463	1463	1463	REACH 8778
FLOW (cfs)	0	0	0	0	0	0	
100	0	0	0	0	0	0	0
150	0	0	0	0	0	0	0
200	0	0	0	0	0	0	0
250	0	0	0	0	0	0	0
300	0	0	0	0	0	0	0
350	0	0	0	0	0	0	0
400	0	0	0	0	0	0	0
450	0	0	0	0	0	0	0
500	0	0	0	0	0	0	0
600	0	0	0	0	0	0	0
700	0	0	0	0	0	0	0
800	0	0	0	0	0	0	0
900	0	0	0	0	0	0	0
1000	0	0	0	0	0	0	0
1250	0	0	0	0	0	0	0
1500	0	0	0	0	0	0	0
1750	0	0	0	0	0	0	0
2000	0	0	0	0	0	0	0
2500	0	0	0	0	0	0	0

Table III-14.
Transect weighted usable area (WUA) in square feet per 1,000 lineal feet of
stream for steelhead trout spawning in the lower Yuba River.

TRANSECT HABITAT TYPE DISTANCE	GARCIA GRAVEL PIT STUDY REACH									WUA in square feet x 1000				
	1	2	3	4	5	6	7	8	9	LGR+	R/G	SP	DP	REACH
	LGR	R/G	R/G	SP	SP	DP	DP	DP	LGR					
FLOW (cfs)	6813	13413	13413	3700	3700	2850	2850	2850	6813	13626	26826	7400	8550	56400
50														
100	0	17218	10266	0	0	0	0	0	8777	60	369	0	0	429
150	0	24361	24991	889	0	0	0	0	14401	98	662	3	0	763
200	0	29936	40292	4106	968	0	0	2	17934	122	942	19	0	1083
250	0	34677	53650	12108	5029	0	0	33	19320	132	1185	63	0	1380
300	0	38713	65296	26343	12342	1	0	138	19198	131	1395	143	0	1669
350	0	42987	75194	41449	21014	27	0	313	17831	121	1585	231	1	1938
400	0	47098	84520	56431	29803	93	3	572	15768	107	1765	319	2	2193
450	0	52538	93870	67704	35450	201	9	802	13581	93	1964	382	3	2442
500	0	59078	100808	73065	39541	529	40	994	11608	79	2145	417	4	2645
600	0	76499	107352	73993	41961	1444	259	1460	9046	62	2466	429	9	2966
700	0	92100	109053	66593	38704	2178	819	2326	7946	54	2698	390	15	3157
800	0	100694	103129	56595	33516	2605	1856	3399	8059	55	2734	333	22	3144
900	0	101702	90595	46221	27903	2557	3181	5100	8846	60	2579	274	31	2944
1000	0	91594	77182	37913	22881	2346	4381	6211	9105	62	2264	225	37	2588
1250	0	54069	46078	23002	12863	1984	6971	8227	9173	62	1343	133	49	1587
1500	0	27561	24235	13495	7518	2159	9128	9277	9834	67	695	78	59	899
1750	0	12294	12875	8831	5203	2451	11137	9087	12364	84	338	52	65	539
2000	0	5350	8865	7626	4856	2514	11810	9295	17414	119	191	46	67	423
2500	0	1462	6563	6599	4889	1909	13757	10761	21397	146	108	43	75	372

Table III-15.

Transect weighted usable area (WUA) in square feet per 1,000 lineal feet of stream for steelhead trout spawning in the lower Yuba River.

TRANSECT HABITAT TYPE DISTANCE	DAGUERRE POINT DAM STUDY REACH							WUA in square feet x 1000				
	1	2	3	4	5	6	7	LGR+	R/G	SP	DP	REACH
	LGR 3088	LGR 3088	R/G 8538	R/G 8538	SP 4688	SP 4688	DP 8775					
FLOW (cfs)								6176	17076	9376	8775	41403
50	1	16	0	0	0	0	0	0	0	0	0	0
100	1278	2518	3715	0	0	0	0	12	32	0	0	44
150	5967	9185	18650	34	0	0	0	47	160	0	0	207
200	12867	15349	41858	1184	0	0	0	87	367	0	0	454
250	19152	20065	63097	4988	0	2	0	121	581	0	0	702
300	24137	22018	80429	9622	1	15	0	143	769	0	0	912
350	26971	22203	90842	15561	2	107	0	152	908	1	0	1061
400	27023	21365	97223	21208	4	434	0	149	1011	2	0	1162
450	25694	20516	98477	25538	7	993	0	143	1059	5	0	1207
500	23569	19117	96283	29239	662	1972	0	132	1072	12	0	1216
600	18493	16042	86185	33993	4845	6507	0	107	1026	53	0	1186
700	14490	13113	72648	35217	11082	14828	4	85	921	121	0	1127
800	11960	11038	58895	34029	17690	22715	12	71	793	189	0	1053
900	10171	9926	46860	31155	22718	28836	31	62	666	242	0	970
1000	9212	9634	36508	28247	25643	30018	50	58	553	261	0	872
1250	8045	8662	23346	21103	27838	23955	204	52	379	243	2	676
1500	7117	6284	15655	17380	26701	14636	374	41	282	194	3	520
1750	6079	4009	11378	18039	25218	7556	581	31	251	154	5	441
2000	5194	4084	8244	20005	23962	3765	1266	29	241	130	11	411
2500	3546	2947	6914	23511	20647	652	2640	20	260	100	23	403

Table III-16.
Transect weighted usable area (WUA) in square feet per 1,000 lineal feet of
stream for steelhead trout spawning in the lower Yuba River.

TRANSECT HABITAT TYPE DISTANCE	SIMPSON LANE STUDY REACH									WUA in square feet x 1000					
	1	2	3	4	5	6	7	8	9	LGR+	R/G	SP	DP	REACH	RIVER
	LGR	R/G	R/G	SP	SP	DP	DP	DP	DP						
	400	1050	1050	1400	1400	3300	3300	3300	3300	400	2100	2800	13200	18500	125075
FLOW (cfs)															
50	1075	0	0	0	0	0	0	0	0	0	0	0	0	0	
100	3263	0	0	0	0	0	0	0	0	1	0	0	0	1	474
150	6061	50	0	0	0	0	0	0	0	2	0	0	0	2	972
200	9397	1930	0	0	0	0	0	0	0	4	2	0	0	6	1543
250	12940	5630	252	0	0	0	0	0	0	5	6	0	0	11	2093
300	16466	9962	723	0	0	0	0	0	0	7	11	0	0	18	2599
350	19679	15711	1505	0	0	0	0	0	0	8	18	0	0	26	3025
400	22545	22086	2418	0	0	0	0	0	0	9	26	0	0	35	3390
450	24284	28399	4055	0	0	0	0	0	0	10	34	0	0	44	3693
500	25034	34607	5935	0	0	0	0	0	0	10	43	0	0	53	3914
600	23943	42917	10043	0	0	0	0	0	0	10	56	0	0	65	4217
700	20975	46352	13563	6	0	0	0	0	0	8	63	0	0	71	4355
800	17274	44940	14548	29	0	0	0	0	0	7	62	0	0	69	4266
900	13944	39877	13926	50	0	0	0	0	0	6	56	0	0	62	3976
1000	10876	33776	12193	65	0	0	0	0	0	4	48	0	0	53	3513
1250	5623	19855	7171	71	0	0	0	0	0	2	28	0	0	31	2294
1500	2900	12336	3544	31	0	0	0	0	0	1	17	0	0	18	1437
1750	1470	8356	1568	0	0	0	0	0	0	1	10	0	0	11	991
2000	758	5627	635	0	0	0	0	0	0	0	7	0	0	7	841
2500	250	2508	97	0	30	0	0	0	0	0	3	0	0	3	778

+ Amount of WUA (sq ft x 1,000) by habitat type within a reach.

APPENDIX IV

WATER QUALITY DATA
FROM THE
LOWER YUBA RIVER

Table IV-1.

Monthly summary (1987) of the Report of Waste Discharge, effluent monitoring, from the Lake Wildwood Special Improvement Zone No. 1, Nevada County Sanitation District No. 1 sewage treatment plant into Deer Creek, tributary to the lower Yuba River, California. (Summary data from CRWQCB files, NPDES No. CA0077828)

Sample Period	EFFLUENT						CONSTITUENT			
	Flow (mgd)	BOD (mg/l)	BOD (lb/d)	Susp matter (mg/l)	Susp matter (lb/d)	Sett matter (ml/l)	Sp con ^{§1} (umhs/cm)	pH (No.)	Tot Col (mpn/100ml)	Cl Res (mg/l)
Jan 1987										
Avg.	0.26	23.7	46.5	21.9	42.5	0.1	584.6	7.1	5.0	0.0
Max.	0.30	36.0	78.1	63.5	137.7	0.2		7.3	110.0	0.0
Min.	0.18	15.7	32.9	6.0	12.5	0.0		7.0	<2.0	0.0
Feb 1987										
Avg.	0.25	19.0	42.0	20.0	56.0	0.0	599.2	7.1	4.0	0.0
Max.	0.37	25.5	69.4	36.5	112.6	0.0		7.3	>2400	0.0
Min.	0.00	14.3	29.8	11.0	23.9	0.0		7.0	<2.0	0.0
Mar 1987										
Avg.	0.45	19.9	73.1	28.8	94.5	0.0	541.8	7.0	240.0	0.0
Max.	0.87	62.2	155.6	83.0	214.6	trace		7.3	>2400	0.0
Min.	0.30	5.3	15.9	4.0	10.0	0.0		6.5	2.0	0.0
Apr 1987										
Avg.	0.31	27.0	68.2	19.3	45.2	0.0	643.0	6.2	240.0	0.0
Max.	0.51	58.0	198.3	39.0	117.1	0.0		8.5	>2400	0.0
Min.	0.25	7.3	3.0	10.0	21.7	0.0		5.9	3.0	0.0
May 1987										
Avg.	0.27	1.3	3.4	7.2	15.8	0.0	510.7	6.1	170.0	0.0
Max.	0.60	3.0	7.5	18.5	46.8	trace		7.0	>2400	0.0
Min.	0.24	<1.0	2.0	0.4	0.9	0.0		4.9	2.0	0.0
Jun 1987										
Avg.	0.30	2.9	7.0	4.3	12.4	0.0	626.5	6.7	33.0	0.0
Max.	0.43	5.1	12.8	17.5	19.0	0.0		7.4	>2400	0.2
Min.	0.24	<1.0	2.5	0.5	1.1	0.0		5.9	<2.0	0.0
Jul 1987										
Avg.	0.33	5.5	14.3	3.3	9.1	0.0	496.4	6.3	31.0	0.0
Max.	0.45	9.6	24.8	9.5	24.6	trace		6.8	>2400	0.0
Min.	0.25	2.2	6.1	0.5	1.1	0.0		3.1	<2.0	0.0
Aug 1987										
Avg.	0.37	5.2	15.6	2.9	8.7	0.0	744.0	6.6	22.0	0.0
Max.	0.48	8.3	25.3	7.2	22.2	trace		7.0	350.0	0.0
Min.	0.28	3.2	9.1	0.4	1.5	0.0		6.2	<2.0	0.0
Sep 1987										
Avg.	0.36	4.2	11.4	4.5	13.6	0.0	763.4	6.2	8.0	0.0
Max.	0.43	8.2	17.8	10.8	32.4	trace		7.0	540.0	0.1
Min.	0.26	0.9	2.4	1.6	3.9	0.0		3.2	2.0	0.0
Oct 1987										
Avg.	0.34	5.2	13.8	3.2	8.8	0.0	650.2	6.4	2.0	0.0
Max.	0.41	9.2	25.2	14.0	39.7	0.0		7.5	110.0	1.2
Min.	0.27	1.1	2.8	1.2	3.0	0.0		3.3	<2.0	0.0
Nov 1987										
Avg.	0.32	9.4	23.2	10.2	27.1	0.0	530.0	6.4	23.0	0.0
Max.	0.39	16.1	38.9	54.0	139.4	trace		7.4	>2400	0.0
Min.	0.26	2.0	4.6	0.4	1.1	0.0		3.9	<2.0	0.0
Dec 1987										
Avg.	0.38	10.5	36.3	1.8	6.0	0.0	504.0	6.4	2.0	0.0
Max.	0.53	11.5	50.8	6.0	14.4	0.0		8.4	5.0	0.0
Min.	0.23	9.4	26.3	0.8	2.3	0.0		4.0	<2.0	0.0

^{§1} Specific conductivity measured monthly.

TDS, measured twice per year, was 20.4 mg/l in June and 264 mg/l in December.

Table IV-2.

Monthly summary (1985) of the Report of Waste Discharge, effluent monitoring, from the City of Nevada City sewage treatment plant into Deer Creek, tributary to the lower Yuba River, California.
(Summary data from CRWQCB files, NPDES No. CA0079901)

Sample Period	EFFLUENT					CONSTITUENT				
	Flow (mgd)	pH (No.)	Tot Col (mpn/100ml)	Cl Res (mg/l)	Sett matter (ml/l)	BOD (mg/l)	BOD (lb/d)	Susp matter (mg/l)	Susp matter (lb/d)	Sp con ^{*1} (umhs/cm)
Jan 1985										
Avg.	0.49	6.7	7.0	0.0	<0.1	99.0	415.0	57.0	226.0	439.0
Max.	0.57	7.0	23.0	0.1	<0.1	225.0	938.0	109.0	454.0	
Min.	0.39	6.4	2.0	0.0	<0.1	55.0	268.0	33.0	103.0	
Feb 1985										
Avg.	0.53	6.8	5.0	0.0	<0.1	76.0	588.0	49.0	230.0	439.0
Max.	1.49	7.2	1600.0	0.1	0.2	132.0	288.0	84.0	686.0	
Min.	0.40	6.4	<2.0	0.0	<0.1	49.0	203.0	25.0	106.0	
Mar 1985										
Avg.	0.52	6.5	2.0	0.4	<0.1	37.0	164.0	27.0	118.0	475.0
Max.	0.92	6.9	5.0	3.0	<0.1	65.0	244.0	37.0	165.0	
Min.	0.43	3.2	<2.0	0.0	<0.1	23.0	92.0	15.0	61.0	
Apr 1985										
Avg.	0.52	6.7	7.0	0.5	<0.1	47.0	203.0	37.0	160.0	626.0
Max.	0.58	7.3	94.0	2.1	0.4	94.0	431.0	74.0	339.0	
Min.	0.47	6.0	<2.0	0.0	<0.1	17.0	69.5	14.0	57.0	
May 1985										
Avg.	0.48	6.0	<2.0	0.8	<0.1	44.0	175.0	54.0	220.0	570.0
Max.	0.52	6.8	79.0	2.2	0.1	94.0	376.0	82.0	328.0	
Min.	0.40	4.6	<2.0	0.0	<0.1	20.0	80.0	31.0	122.0	
Jun 1985										
Avg.	0.51	6.5	13.0	0.5	<0.1	19.0	82.0	32.0	137.0	582.0
Max.	0.55	6.9	79.0	3.0	0.5	29.0	123.0	44.0	198.0	
Min.	0.46	5.5	<2.0	0.0	<0.1	12.0	50.0	15.0	62.0	
Jul 1985										
Avg.	0.47	6.8	8.0	2.0	<0.1	19.0	76.0	21.0	84.0	457.0
Max.	0.52	7.1	350.0	2.0	<0.1	29.0	121.0	35.0	146.0	
Min.	0.44	6.3	2.0	0.0	<0.1	4.0	17.0	5.0	21.0	
Aug 1985										
Avg.	0.49	6.2	18.0	0.7	<0.1	8.0	33.0	11.0	50.0	517.0
Max.	0.52	6.8	>2400	5.0	0.2	13.0	55.0	20.0	81.0	
Min.	0.46	5.2	<2.0	0.0	<0.1	5.0	20.0	5.5	28.0	
Sep 1985										
Avg.	0.49	6.4	<2.0	0.1	<0.1	14.0	58.0	18.0	72.0	541.0
Max.	0.60	6.9	33.0	1.5	<0.1	23.0	86.0	24.0	108.0	
Min.	0.44	5.4	<2.0	0.0	<0.1	8.0	34.0	10.0	42.0	
Oct 1985										
Avg.	0.48	6.2	<2.2	0.4	<0.1	9.0	36.1	8.0	30.0	529.0
Max.	0.57	7.2	>2400	2.0	<0.1	17.0	76.0	10.0	41.0	
Min.	0.40	3.6	<2.0	0.0	<0.1	5.0	20.0	5.0	19.0	
Nov 1985										
Avg.	0.57	6.3	<2.0	0.1	<0.1	12.0	50.0	16.0	67.0	591.0
Max.	1.03	7.0	23.0	2.0	<0.1	18.0	75.0	34.0	142.0	
Min.	0.47	4.2	<2.0	0.0	<0.1	6.0	24.0	7.0	31.0	
Dec 1985										
Avg.	0.56	6.3	<2.0	0.1	<0.1	<10	<51	8.0	44.0	—
Max.	1.12	7.7	8.0	2.0	<0.1	23.0	112.0	17.0	159.0	
Min.	0.46	3.3	<2.0	0.0	<0.1	<1	<5	2.0	8.0	

*1 Specific conductivity measured monthly.

TDS, measured twice per year, was 245 mg/l in June and 276 mg/l in November.

Table IV-3.

Monthly summary (1986) of the Report of Waste Discharge, effluent monitoring, from the City of Nevada City sewage treatment plant into Deer Creek, tributary to the lower Yuba River, California. (Summary data from CRWQCB files, NPDES No. CA0079901)

Sample Period	EFFLUENT					CONSTITUENT				
	Flow (mgd)	pH (No.)	Tot Col (apn/100ml)	Cl Res (mg/l)	Sett matter (ml/l)	BOD (mg/l)	BOD (lb/d)	Susp matter (mg/l)	Susp matter (lb/d)	Sp con ^{§1} (umhs/cm)
Jan 1986										
Avg.	0.58	6.5	<2.0	0.1	<0.1	9.0	51.0	4.0	24.0	606.0
Max.	1.07	7.0	4.0	0.8	<0.1	19.0	105.0	9.0	72.0	
Min.	0.43	5.4	<2.0	0.0	<0.1	4.0	20.0	1.5	4.0	
Feb 1986										
Avg.	0.51	5.7	<2.0	<0.1	<0.1	6.0	24.0	3.0	13.0	492.0
Max.	1.40	6.7	2.0	1.0	<0.1	9.0	59.0	7.0	49.0	
Min.	0.19	3.2	<2.0	0.0	<0.1	1.0	5.0	2.0	4.0	
Mar 1986										
Avg.	0.79	5.7	<2.0	<0.1	0.1	8.0	54.0	9.0	61.0	411.0
Max.	1.60	6.7	8.0	0.7	0.1	19.0	152.0	25.0	200.0	
Min.	0.48	3.5	<2.0	0.0	0.1	5.0	20.0	2.0	11.0	
Apr 1986										
Avg.	0.50	6.6	<2.0	0.0	0.1	7.0	30.0	8.0	27.0	466.0
Max.	0.61	7.0	17.0	0.5	0.1	10.0	43.0	15.0	34.0	
Min.	0.39	6.0	<2.0	0.0	0.1	6.0	20.0	4.0	17.0	
May 1986										
Avg.	0.50	6.4	<2.0	0.0	<0.1	5.0	21.0	5.0	21.0	--
Max.	0.57	6.8	79.0	0.0	<0.1	8.0	35.0	9.0	40.0	
Min.	0.44	6.1	<2.0	0.0	<0.1	2.0	8.0	2.0	8.0	
Jun 1986										
Avg.	0.51	6.1	<2.0	0.0	<0.1	5.0	22.0	6.0	26.0	600.0
Max.	0.54	6.7	2.0	0.0	<0.1	7.0	30.0	9.0	38.0	
Min.	0.43	2.6	<2.0	0.0	<0.1	4.0	15.0	3.0	11.0	
Jul 1986										
Avg.	0.51	6.3	<2.0	0.0	<0.1	5.0	24.0	6.0	28.0	--
Max.	0.59	6.6	8.0	0.0	<0.1	9.0	37.0	13.0	53.0	
Min.	0.48	5.8	<2.0	0.0	<0.1	4.0	17.0	2.0	9.0	
Aug 1986										
Avg.	0.51	6.0	<2.0	0.0	<0.1	5.0	22.0	5.0	20.0	417.0
Max.	0.59	7.0	13.0	0.0	<0.1	6.0	29.0	6.0	29.0	
Min.	0.49	3.8	<2.0	0.0	<0.1	3.0	12.0	3.0	12.0	
Sep 1986										
Avg.	0.55	5.6	<2.0	<0.1	<0.1	9.0	38.0	11.0	51.0	460.0
Max.	0.79	6.5	2.0	1.0	0.2	15.0	68.0	27.0	115.0	
Min.	0.41	3.3	<2.0	0.0	<0.1	4.0	19.0	<1.0	<5	
Oct 1986										
Avg.	0.43	6.0	<2.0	0.1	<0.1	10.0	34.0	7.0	24.0	474.0
Max.	0.51	6.5	<2.0	2.0	0.1	17.0	62.0	10.0	39.0	
Min.	0.38	5.0	<2.0	0.0	<0.1	6.0	21.0	4.0	10.0	
Nov 1986										
Avg.	0.40	5.7	<2.0	0.1	<0.1	13.0	44.0	14.0	46.0	443.0
Max.	0.50	6.4	2.0	2.0	<0.1	20.0	68.0	21.0	70.0	
Min.	0.34	4.6	<2.0	0.0	<0.1	9.0	26.0	8.0	25.0	
Dec 1986										
Avg.	0.41	5.6	<2.0	0.0	<0.1	20.0	69.0	17.0	60.0	561.0
Max.	0.51	6.3	2.0	0.0	<0.1	39.0	130.0	27.0	90.0	
Min.	0.33	5.1	<2.0	0.0	<0.1	12.0	42.0	10.0	30.0	

§1 Specific conductivity measured monthly.
TDS, measured once in 1986, was 265 mg/l in November.

Table IV-4.

Monthly summary (1987) of the Report of Waste Discharge, effluent monitoring, from the City of Nevada City sewage treatment plant into Deer Creek, tributary to the lower Yuba River, California.
(Summary data from CRWQCB files, NPDES No. CA0079901)

Sample Period	Flow (mgd)	EFFLUENT					CONSTITUENT			
		PH (No.)	Tot Col (mpn/100ml)	Cl Res (mg/l)	Sett matter (ml/l)	BOD (mg/l)	BOD (lb/d)	Susp matter (mg/l)	Susp matter (lb/d)	Sp con (umhs/cm) ^{*1}
Jan 1987										
Avg.	0.44	6.5	<2.0	0.1	<0.1	14.0	48.0	14.0	51.0	472.0
Max.	0.86	7.0	4.0	2.0	<0.1	21.0	90.0	28.0	126.0	
Min.	0.33	6.0	<2.0	0.0	<0.1	6.0	22.0	4.0	15.0	
Feb 1987										
Avg.	0.50	6.6	<2.0	0.0	<0.1	8.0	40.0	7.0	33.0	390.0
Max.	1.09	6.8	<2.0	0.0	<0.1	14.0	91.0	12.0	73.0	
Min.	0.37	6.1	<2.0	0.0	<0.1	6.0	22.0	3.0	10.0	
Mar 1987										
Avg.	0.52	6.5	<2.0	0.0	<0.1	9.0	47.0	4.0	21.0	485.0
Max.	0.89	7.0	<2.0	0.5	<0.1	12.0	88.0	6.0	59.0	
Min.	0.38	2.5	<2.0	0.0	<0.1	6.0	23.0	1.0	5.0	
Apr 1987										
Avg.	0.40	6.6	<2.0	0.0	<0.1	11.0	35.0	15.0	50.0	523.0
Max.	0.45	7.2	8.0	0.0	<0.1	19.0	70.0	49.0	180.0	
Min.	0.35	6.3	<2.0	0.0	<0.1	6.0	20.0	5.0	23.0	
May 1987										
Avg.	0.40	6.4	<2.0	0.0	<0.1	7.0	23.0	11.0	38.0	516.0
Max.	0.47	6.7	8.0	0.0	<0.1	11.0	34.0	20.0	62.0	
Min.	0.34	6.0	<2.0	0.0	<0.1	4.0	14.0	6.0	22.0	
Jun 1987										
Avg.	0.37	6.3	<2.0	0.0	<0.1	7.0	22.0	9.0	27.0	548.0
Max.	0.42	6.5	4.0	0.0	<0.1	16.0	48.0	20.0	57.0	
Min.	0.33	5.9	<2.0	0.0	<0.1	1.0	3.0	1.0	3.0	
Jul 1987										
Avg.	0.36	6.3	<2.0	0.0	<0.1	7.0	22.0	6.0	20.0	531.0
Max.	0.44	6.8	>2400	0.0	<0.1	9.0	29.0	11.0	34.0	
Min.	0.32	5.9	<2.0	0.0	<0.1	4.0	14.0	3.0	9.0	
Aug 1987										
Avg.	0.32	6.3	<2.0	0.0	<0.1	10.0	25.0	9.0	23.0	516.0
Max.	0.36	6.5	2.0	0.0	<0.1	19.0	44.0	14.0	34.0	
Min.	0.28	5.5	<2.0	0.0	<0.1	5.0	17.0	5.0	14.0	
Sep 1987										
Avg.	0.32	6.5	<2.0	0.0	<0.1	10.0	26.0	11.0	27.0	609.0
Max.	0.38	6.7	22.0	1.0	<0.1	13.0	33.0	14.0	35.0	
Min.	0.28	6.2	<2.0	0.0	<0.1	7.0	16.0	8.0	19.0	
Oct 1987										
Avg.	0.37	6.7	<2.0	0.0	<0.1	10.0	45.0	9.0	27.0	516.0
Max.	0.41	7.0	>2400	0.0	<0.1	16.0	112.0	16.0	48.0	
Min.	0.31	6.3	<2.0	0.0	<0.1	6.0	17.0	4.0	14.0	
Nov 1987										
Avg.	0.37	6.6	<2.0	0.0	<0.1	12.0	33.0	5.0	16.0	516.0
Max.	0.58	6.7	17.0	0.0	<0.1	28.0	79.0	9.0	29.0	
Min.	0.33	6.3	<2.0	0.0	<0.1	5.0	15.0	2.0	6.0	
Dec 1987										
Avg.	0.47	6.4	<2.0	0.0	<0.1	13.0	46.0	5.0	18.0	523.0
Max.	0.76	6.7	<2.0	0.0	<0.1	42.0	140.0	11.0	37.0	
Min.	0.34	5.7	<2.0	0.0	<0.1	6.0	21.0	1.0	35.0	

*1 Specific conductivity measured monthly.

TDS, measured twice/year, was 336 mg/l in September and 272 mg/l in December.

Table IV-5.

Summary of measurements of dissolved oxygen concentrations in
the lower Yuba River, California (from STORET).

<u>Dissolved Oxygen</u>						
Date(s) Sampled	Number of Samples	Minimum (mg/L)	Maximum (mg/L)	Mean (mg/L)	Standard Deviation (mg/L)	Location Code * Source of Data *
05-20-71	1			9.8		EB CURCB
04-10-51 to 09-05-69	177	7.5	14.0	10.5	1.5	PD CURCB
10-16-67 to 04-23-68	2	9.9	11.5	10.7	1.1	DB CURCB
10-16-67 to 09-24-80	41	7.3	12.7	10.6	1.2	NH USGS
04-09-51 to 12-16-76	244	7.4	14.5	10.5	1.5	AM CURCB
10-03-72 to 09-20-76	16	8.1	12.8	10.6	1.4	AM USGS
Weighted Mean	N=481			10.5	1.5	

* Key to Location Code and Source of Data:

EB = Below Englebright Dam (USGS Station 11418000)
 PD = At Parks Bar
 DB = Daguerre Point Dam
 NH = Near Marysville (USGS Station 11421000)
 AM = At Marysville
 CURCB = California State Water Resources Control Board
 USGS = U.S. Geological Survey

Table IV-6.

Summary of measurements of pH the lower Yuba River, California (from STORET).

Date(s) Sampled	Number of Samples	PH Values				Location Code *	Source of Data *
		Minimum	Maximum	Mean	Standard Deviation		
05-20-71	1			7.2		EB	CWRCB
10-03-60 to 05-05-66	51	7.2	8.2	7.8	0.2	ST	USGS
04-10-51 to 09-05-69	173	6.7	8.4	7.4	0.3	PB	CWRCB
10-16-67 to 04-23-68	2	7.7	8.1	7.9	0.3	DB	CWRCB
10-16-67 to 09-24-80	42	7.1	8.6	7.4	0.2	NH	USGS
10-03-60 to 09-20-76	68	7.1	8.2	7.6	0.3	AN	USGS
04-09-51 to 12-16-76	244	6.6	8.0	7.3	0.2	AN	CWRCB
Weighted Mean	N=583			7.4	0.2		

* Key to Location Code and Source of Data:

EB = Below Englebright Dam (USGS Station 11418000)
 ST = Near Smartville
 PB = At Parks Bar
 DB = Daguerre Point Dam
 NH = Near Marysville (USGS Station 11421000)
 AN = At Marysville
 CWRCB = California State Water Resources Control Board
 USGS = U.S. Geological Survey

Summary of measurements of total dissolved solids concentrations in the lower Yuba River, California (from STORET)

Total Dissolved Solids

Table IV-7.

Date(s) Sampled	Number of Samples	Standard			Code of Source	of Data
		Minimum (mg/L)	Maximum (mg/L)	Mean Deviation (mg/L)		
05-04-61 to 05-05-66	11	28.0	84.0	60.7	ST	USGS
09-10-62 to 04-23-68	10	29.0	90.0	60.1	PS	CWRCB
12-16-76 to 09-24-80	42	40.0	85.0	60.5	NM	USGS
05-07-51 to 12-16-76	33	36.0	100.0	60.5	AM	CWRCB
05-04-61 to 09-20-76	24	32.0	107.0	60.0	AM	USGS
Weighted Mean	N=120			60.4		15.9

* Key to Location Code and Source of Data:

ST = Near Smartville
 PS = At Parks Bar
 NM = Near Marysville (USGS Station 11421000)
 AM = At Marysville
 CWRCB = California State Water Resources Control Board
 USGS = U.S. Geological Survey

Summary of principal inorganic constituents of total dissolved solids
in the lower Yuba River, California (from STORET).

Table IV-8.

Inorganic Constituents

Parameter	Date(s) Sampled	Number of Samples	Minimum (mg/L)	Maximum (mg/L)	Mean Deviation (mg/L)	Standard Deviation (mg/L)	Location	Source of Data
Carbonate (CO_3^{--})	11-05-65 to 09-28-77	30	0.0	0.0	0.0	0.0	ST, NM, AM	USGS
Bicarbonate (HCO_3^-)	10-03-60 to 05-26-78	133	19.0	84.0	47.6	13.8	ST, NM, AM	USGS
Chloride (Cl^-)	04-09-51 to 09-24-80	520	0.0	7.0	1.5	1.0	ST, DG, NM, AM	USGS, CURCB
Sulfate (SO_4^{--})	05-07-51 to 09-24-80	139	0.0	17.0	5.0	3.0	ST, PB, NM, AM	USGS, CURCB
Nitrate (NO_3^-)	05-07-51 to 09-24-80	182	0.0	5.6	0.2	0.4	ST, PB, NM, AM	USGS, CURCB
Sodium (Na^+)	04-09-51 to 09-24-80	510	1.0	6.0	2.7	0.8	ST, PB, DG, NM, AM	USGS, CURCB
Potassium (K^+)	05-07-51 to 09-24-80	216	0.0	5.0	0.6	0.3	ST, PB, NM, AM	USGS, CURCB
Calcium (Ca^{++})	05-07-51 to 09-24-80	261	3.65	20	10.5	3.5	ST, PB, DG, NM, AM	USGS, CURCB
Magnesium (Mg^{++})	05-07-51 to 09-24-80	237	0.7	6.6	3.2	1.2	ST, PB, DG, NM, AM	USGS, CURCB

* Key to Location Code and Source of Data:

- ST = Near Smartville
- PB = At Parks Bar
- DG = Daguerre Point Dam
- NM = Near Marysville (USGS station 11421000)
- AM = At Marysville
- CURCB = California State Water Resources Control Board
- USGS = U.S. Geological Survey

Table IV-9.

Summary of measurements of water hardness as CaCO_3 in the lower Tuba River, California (from STORET).

Water Hardness

Date(s) Sampled	Number of Samples	Minimum (mg/L)	Maximum (mg/L)	Mean Deviation (mg/L)	Standard	Location	Code	Source	of Data
10-03-60 to 05-05-66	51	19.0	62.0	39.1	11.7	ST		USGS	
03-10-51 to 09-05-69	176	17.0	67.0	39.2	12.6	PS		CNRCS	
10-06-67 to 04-23-68	2	32.0	52.0	42.0	14.1	DS		CNRCS	
12-16-76 to 09-24-80	42	23.0	56.0	37.7	9.7	NH		USGS	
04-09-51 to 12-16-76	198	18.0	96.0	43.3	15.2	AM		CNRCS	
10-03-60 to 09-20-76	65	18.0	86.0	42.9	15.4	AM		USGS	
N=534 Weighted Mean									
41.8									
14.3									

* Key to Location Codes

ST = Near Smartville
 PS = At Parks Bar
 DS = Daguerre Point Dam
 NH = Near Marysville (USGS station 11421000)
 AM = At Marysville
 CNRCS = California State Water Resources Control Board
 USGS = U.S. Geological Survey

Table IV-10.

Summary of measurements of total alkalinity as CaCO_3 in the lower Yuba River, California.
Data retrieved from STORET.

Date(s) Sampled	Number of Samples	Minimum Value (mg/L)	Maximum Value (mg/L)	Mean Value (mg/L)	Standard Deviation (mg/L)	Location Code	Original Source of Data
04-10-51 to 09-05-69	177	17.0	62.0	37.8	11.7	ST	USGS
10-16-67 to 04-23-68	2	33.0	49.0	41.0	12.6	PB	CMCB
12-16-76 to 09-26-80	42	21.0	52.0	35.6	14.1	DG	CMCB
04-09-51 to 12-16-76	198	16.0	369.0	41.9	9.7	MM	USGS
10-03-72 to 09-20-76	13	20.0	45.0	34.5	15.2	AM	CMCB
Weighted Mean	N=432			39.4	18.1		

Key to Location Code and Source of Data:

ES=Below Englebright Dam (USGS station 11418000)
ST=Near Smartville
PB=At Parks Bar
DG=At Daguerre Point Dam
MM=Near Marysville (USGS station 11421000)
USGS=U.S. Geological Survey
CMCB=California State Water Resources Control Board
AM = At Marysville

Summary of measurements of turbidity in the lower Yuba River, California
(from STORET).

Table IV-11.

Turbidity						
Number	Units of	Minimum	Maximum	Mean	Standard Deviation	Location Source
Date(s) Sampled						
of Samples						
Weighted Mean						
N=120						
14	ppm s10 ₂	1.0	40.0	8.8	12.8	PS
1	ppm s10 ₂			5.0		DG
1	JTU			1.0		NH
1	JTU			0.0		NH
13	JTU	0	15.0	2.4	4.1	USGS
15	JTU	0	15.0	2.5		AN
75	ppm s10 ₂	0	310.0	25.8	44.5	AN
04-09-51 to 05-04-71						CUNCB
03-02-72 to 12-16-76						CUNCB
10-03-72 to 09-20-76						USGS
04-24-79						USGS
12-16-76						USGS
04-23-68						CUNCB
11-05-65 to 09-05-69						CUNCB

Note: JTU = Formazin Turbidity Unit
JTU = Jackson Turbidity Unit
JTUs are comparable to JTUs (USEPA 1974)
Assume that one JTU = one ppm on a silica scale (Boell 1986)

** Key to Location Code and Source of Data:

PS = At Parks Bar
DG = Daguerre Point Dam
NH = Near Marysville (USGS Station 11421000)
AN = At Marysville
CUNCB = California State Water Resources Control Board
USGS = U.S. Geological Survey

Tabl IV-12.

Summary of measurements of nitrates, nitrites, and ammonia concentrations in the lower Yuber River, California.
Data retrieved from STORET.

Date(s) Sampled	Number of Samples	Concentration of Nitrogen (N)				Location Code ^a	Original Source of Data ^b
		Minimum Value (mg/L as N)	Maximum Value (mg/L as N)	Mean Value (mg/L as N)	Standard Deviation (mg/L as N)		
Nitrates							
02/25/70 to 12/08/70	18	0	0.47	0.075	0.11	AM	CWRCB
05/07/51 to 04/23/68	36	0	5.60	0.44	0.98	AM	CWRCB
05/14/61 to 05/05/66	11	0	1.10	0.42	0.42	ST	USGS
05/04/61 to 05/05/66	12	0	5.60	0.78	1.57	AM	USGS
05/08/51 to 04/23/68	35	0	1.20	0.24	0.39	PB	CWRCB
03/01/77 to 09/24/80	35	0	0.15	0.031	0.041	NM	USGS
03/01/77 to 09/24/80	35	0	0.70	0.13	0.18	NM	USGS
Weighted Mean	N=182			0.248	0.451		
Nitrites							
09/28/77 to 10/27/78	7	0.010	0.010	0.010	0	NM	USGS
03/01/77 to 01/25/79	16	0.01				NM	USGS
03/01/77 to 01/25/79	23	0	0.03	0.009	0.014	NM	USGS
Weighted Mean	N=46			0.009	0.007		
Ammonia							
03/24/77 to 12/28/78	14	0.010	0.130	0.030	0.033	NM	USGS
02/26/79 to 09/24/80	18	0	0.03	0.010	0.013	NM	USGS
Weighted Mean	N=32			0.019	0.022		

a. Location Codes:

ST = Near Smartville
PB = At Parks Bar
NM = Near Marysville (USGS Station 11421000)
AM = At Marysville

b. Data Source Codes

CWRCB = California State Water Resources Control Board
USGS = U.S. Geological Survey

Summary of measurements of total phosphorus in the lower Yuba River, California.
Data retrieved from STORET.

Table IV-13.

Total Phosphorus (P)									
Number of of Sample Measurements	Unit	Minimum Value	Maximum Value	Mean	Standard Deviation	Location Code	Original Source of Data	Date(s) Sampled	
21	mg/L as P	0	0.08	0.022	0.019	MM	CUMCB	05/07/65 to 12/08/70	05/05/66
1	mg/L as P	0				PB	CUMCB	03/01/77 to 09/26/80	08/25/77 to 09/20/79
32	mg/L as P	0	0.050	0.015	0.0098	MM	USGS		
9	mg/L as P	0.010				MM	USGS		
Weighted Mean*		N=63		0.016	0.013				

EA = Below Englishlight Dam (USGS station 11418000)
PB = At Parks Bar
DG = Daguerre Point Dam
MM = Near Marysville (USGS station 11421000)
AM = At Marysville
CUMCB = California State Water Resources Control Board
USGS = U.S. Geological Survey

*Note: In calculating weighted mean, the threshold value of 0.010 mg/L for the 9 samples of 08/25/77 to 09/20/79 was conservatively assumed to represent a mean value.

Table IV-14.

Summary of EPA(1986) criteria for selected trace elements and measurements of these elements in the lower Yuba River, California

Parameter	Toxicity Level		Dates Sampled	Number of Samples	Sample Medium	Measurement Unit	Concentration				Location Code(b)	Source of Data(c)
	Acute	Chronic					Minimum Value(a)	Maximum Value	Mean Value	Standard Deviation		
Aluminum	None	None	5/7/65 to 9/15/66	5	Water	ug/L	0	46.0	20.1	19.1	AM	CLWCB
Antimony	9000	1600	2/19/80	1	Water	ug/L	289.00(k)				NM	USEPA
			8/4/80	1	Sediment	Mg/Kg(dry wt.)	778.92(k)				NM	USEPA
			8/4/80	1	Tissue	Mg/Kg(wet wt.)	8.00(k)				NM	USEPA
Arsenic (Pent) (Tri)	850 360	48 190	8/19/80	1	Water	ug/L	1247.00(k)					USEPA
			8/4/80	1	Sediment	Mg/Kg(dry wt.)	183.02(k)					USEPA
			8/4/80	1	Tissue	Mg/Kg(wet wt.)			13.00			USEPA
			6/29/77	3	Tissue	Mg/Kg(wet wt.)	0	0.80	0.27	0.46		CLWCB
			4/22/80 to 9/24/80	2	Water	ug/L	0	0	0	0	NM	USGS
			4/21/77 to 9/20/79	6	Water	ug/L	1.0(k)				NM	USGS
			5/7/65 to 5/20/71	7	Water	ug/L	0	10.00	1.43	3.78	AM	CLWCB
			5/5/66 to 9/2/66	2	Water	ug/L	0	0	0	0	PM	CLWCB
			5/20/71	1	Water	ug/L			0		EB	CLWCB
Barium	N/A	N/A	5/20/71	1	Water	ug/L			0		EB	CLWCB
			6/19/67 to 5/20/71	3	Water	ug/L	0	100.00	33.33	57.74	AM	CLWCB
			11/30/79 to 9/24/80	4	Water	ug/L	0	1.00	0.50	0.58	NM	USGS
			4/21/77 to 9/20/79	6	Water	ug/L	100.00(k)				NM	USGS
Beryllium	130	5.3	5/7/65 to 9/15/66	5	Water	ug/L	0	0	0	0	AM	CLWCB
			2/19/80	1	Water	ug/L	26.00(k)				NM	USEPA
			8/4/80	1	Sediment	Mg/Kg(dry wt.)	4.40(k)				NM	USEPA
			8/4/80	1	Tissue	Mg/Kg(wet wt.)	0.30(k)				NM	USEPA
Boron	N/A	N/A	10/3/60 to 5/5/66	52	Water	ug/L	0	100.00	15.38	36.43	AM	USGS
			5/7/51 to 4/23/68	157	Water	ug/L	0	280.00	25.92	48.08	AM	CLWCB
			10/3/60 to 5/5/66	51	Water	ug/L	0	100.00	13.73	34.75	SMT	USGS
			9/20/79 to 9/24/80	11	Water	ug/L	0	100.00	9.09	30.15	NM	USGS
			3/1/77 to 8/23/79	29	Water	ug/L	20.00(k)				NM	USGS
Cadmium	3.9	1.1	8/19/80	1	Water	ug/L	88.0(k)					USEPA
			8/4/80	1	Mud	Mg/Kg(dry wt.)	13.18(k)					USEPA
			8/4/80	1	Tissue	Mg/Kg(wet wt.)	1.00(k)					USEPA
			8/4/80	1	Tot. Fish	Mg/Gm(dry wt.)			3.0			USEPA
			6/29/77	3	Tissue	Mg/Kg(wet wt.)	0	0.10	0.03	0.058		CLWCB
			4/22/80 to 9/24/80	2	Water	ug/L	0	10.00	5.00	7.07	NM	USGS
			9/20/79	1	Water	ug/L	20.00(k)				NM	USGS
			4/21/77 to 3/15/79	5	Water	ug/L	0(u)	0	0	0		USGS
			5/7/65 to 5/4/71	6	Water	ug/L	0	0	0	0	AM	CLWCB
			5/20/71	1	Water	ug/L			0		EB	CLWCB

Table IV-16.

Summary of EPA(1986) criteria for selected trace elements and measurements of these elements in the lower Yuba River, California

Parameter	Toxicity Level		Dates Sampled	Number of Samples	Sample Medium	Measurement Unit	Concentration				Location Code(b)	Source of Data(c)
	Acute	Chronic					Minimum Value(a)	Maximum Value	Mean Value	Standard Deviation		
Mercury	2.4	0.012	1976	6	Sediment	ppb	54	360	150.83		RB+NM	Beak
			8/19/80	1	Water	ug/L	0.20(k)					USEPA
			8/4/80	1	Sediment	Mg/Kg(dry wt.)			1464.00			USEPA
			8/4/80	1	Tissue	Mg/Kg(wet wt.)			0.90			USEPA
			12/8/76 to 6/29/77	4	Fish	ppm (wet wt.)	0.40	2.00	1.20	0.73		CWRCB
			6/29/77	1	Fish	ppm (wet wt.)	0(u)	0	0	0		CWRCB
			4/21/77 to 9/28/77	2	Water	ug/L	0.50(k)				NM	USGS
			4/22/80 to 9/24/80	2	Water	ug/L	0	0	0	0	NM	USGS
			5/4/71 to 5/20/71	2	Water	ug/L	0.20	0.20	0.20	0	AM	CWRCB
			5/20/71	1	Water	ug/L			0		EB	CWRCB
			1976	6	Water	ppb	0.25(k)				RB+NM	Beak
Nickel	1400	160	8/19/80	1	Water	ug/L	91.00(k)					USEPA
			8/4/80	1	Sediment	Mg/Kg(dry wt.)			159.59			USEPA
			8/4/80	1	Tissue	Mg/Kg(wet wt.)	1.00(k)					USEPA
			6/29/77	2	Tissue	Mg/Kg(wet wt.)	0.30	0.70	0.50	0.28		CWRCB
			12/8/76 to 6/29/77	3	Tissue	Mg/Kg(wet wt.)	0(u)	0	0	0		CWRCB
			5/7/65 to 9/15/66	5	Water	ug/L	0	3.00	1.86	1.35	AM	CWRCB
Selenium	280	35	12/8/76	2	Tissue	Mg/Kg(wet wt.)	0(u)	0	0	0		CWRCB
			3/15/79 to 9/24/80	3	Water	ug/L	0	10.00	6.67	5.77	NM	USGS
			4/21/77 to 9/20/79	5	Water	ug/L	1.00(k)				NM	USGS
			5/4/71 to 5/20/71	2	Water	ug/L	0	0	0	0	AM	CWRCB
			5/20/71	1	Water	ug/L			0		EB	CWRCB
Silver	4.1+	0.12	6/29/77	3	Fish	Mg/Kg	0(u)	0	0	0	NM	CWRCB
			6/19/67	1	Water	ug/L			0		AM	CWRCB
Zinc	120	110	8/19/80	1	Water	ug/L			77.00			USEPA
			8/4/80	1	Sediment	Mg/Kg(dry wt.)			455.34			USEPA
			8/4/80	1	Tissue	Mg/Kg(wet wt.)			48.00			USEPA
			12/8/76 to 6/29/77	5	Tissue	Mg/Kg(wet wt.)	6.50	35.40	18.58	11.51		CWRCB
			5/7/65 to 6/19/67	5	Water	ug/L	0	0	0	0	AM	CWRCB

a. Minimum value codes:

k = Threshold value. Actual concentration was less than threshold value.

u = Undetected. Actual concentration was less than analytic detection limit.

b. Location codes (i.e., general location sample was taken):

EB = Below Englebright Dam (USGS Station 11418000)

PB = At Parks Bar

DG = At Daguerre Point Dam

NM = Near Marysville (USGS Station 11421000)

AM = At Marysville

ST = Near Smartville

RB = Rose Bar

c. Data Source Codes:

CWRCB = California State Water Resources Control Board

USGS = U.S. Geological Survey

USEPA = U.S. Environmental Protection Agency

Beak = Beak Consultants Incorporated (1976)

Table IV-17.

Summary of measurements of selected organochlorine insecticides in the lower Yuba River, California.

					Concentration				Source of Data ^b
Date(s) Sampled	Number of Samples	Sample Medium	Measurement Unit	Minimum Value ^a	Maximum Value	Mean Value	Standard Deviation		
<u>D.D. - DDT</u>									
08/19/80	1	Water	ug/L	50.00(k)					USEPA USEPA USEPA CWRCB
08/04/80	1	Sediment	mg/kg dry wt.	1830.00(k)					
08/04/80	1	Tissue	mb/kg wet wt.	0.05(k)					
06/27/77	3	Tissue	mg/kg wet wt.	0	0.02	0.01	0.0090		
<u>D.D. - DDD</u>									
08/19/80	1	Water	ug/L	50.00(k)					USEPA WSEPA USEPA CWRCB CWRCB
08/09/80	1	Sediment	mg/kg dry wt.	1830.00(k)					
08/04/80	1	Tissue	mg/kg wet wt.	0.05(k)					
06/08/76 to 06/29/77	5	Tissue	mg/kg wet wt.	0.02	0.35	0.10	0.14		
12/08/76	1	Tissue	mg/kg wet wt.			0(u)			
<u>D.D. - DDE</u>									
08/19/80	1	Water	ug/L	50.00(k)					USEPA USEPA USEPA CWRCB
08/09/80	1	Sediment	mg/kg dry wt.	1830.00(k)					
08/04/80	1	Tissue	mg/kg wet wt.	0.50(k)					
12/08/76 to 06/29/77	6	Tissue	mg/kg wet wt.	0.03	0.94	0.28	0.35		
<u>Total DDT</u>									
12/08/76 to 06/29/77	5	Tissue	mg/gm	0.01	1.62	0.45	1.69		CWRCB CWRCB
12/08/76	1	Tissue	mg/gm			0(u)			

a. Minimum Value Codes:

K-Threshold value. Actual concentration was less than threshold value.

U-Undetected. Actual concentration was less than analytical detection limit.

b. Data Source Codes:

CWRCB-California State Water Resources Control Board

USEPA-U.S. Environmental Protection Agency

Table IV-18.

Summary of Polychlorinated Biphenyls (PCB) measurements in the lower Yuba River, California.

				<u>Concentration</u>					Source of Data ^b
Date(s) Sampled	Number of Samples	Sample Medium	Measurement Unit	Minimum Value ^a	Maximum Value	Mean Value	Standard Deviation		
<u>PCB - (form)</u>									
{1016, 1221, 1232, 1242, 1248, 1254, 1260}	08/04/80	1	Tissue	mg/kg wet wt.	0.05(k)				USEPA
	08/19/80	1	Water	ug/L	50.05(k)				USEPA
	08/04/80	1	Sediment	mg/kg dry wt.	1830.00(k)				USEPA
{1260}	06/29/77	3	Tissue	mg/kg wet wt.	0	0.22	0.07	0.13	CURCB
{all forms}	12/08/76	3	Fish	mg/kg wet wt.	0	1.10	0.42	0.60	CURCB

a. Minimum Value Codes:

k = Threshold value. Actual concentration was less than threshold value.

u = Undetected. Actual concentration was less than analytical detection limit.

b. Data Source Codes:

CWRCS = California State Water Resources Control Board

USEPA = U.S. Environmental Protection Agency

APPENDIX V

**1965 AGREEMENT BETWEEN
THE YUBA COUNTY WATER AGENCY
AND
THE CALIFORNIA DEPARTMENT OF FISH AND GAME**

A G R E E M E N T

THIS AGREEMENT, made this 2nd day of September, 1965, between the YUBA COUNTY WATER AGENCY, hereinafter called "AGENCY" and the STATE OF CALIFORNIA, represented by the CALIFORNIA DEPARTMENT OF FISH AND GAME, hereinafter called "STATE", supersedes and replaces the preliminary agreement dated December 28, 1961, and the agreement dated November 23, 1962, between the parties hereto.

W I T N E S S E T H :

WHEREAS, the Yuba River and its tributaries comprise a natural river system frequented by king salmon, steelhead trout, brown trout, rainbow trout, shad, and other fish; and

WHEREAS, the Water Rights Board of the State of California has issued its Decision No. D1159 adopted December 19, 1963, and amended February 17, 1964, wherein Applications Nos. 5631, 5632, 15204, 15205, 15563, and 15574 of the AGENCY were approved under the terms and conditions of said decision, and permits were ordered to be issued to the AGENCY for the diversion and use of certain quantities of water from the Yuba River System for irrigation and municipal purposes and for the generation of electrical power; and

WHEREAS, the AGENCY has obtained a license from the FEDERAL POWER COMMISSION for the construction of the Yuba River Development designated in the Federal Power Commission proceedings as Project No. 2246; and

WHEREAS, since the issuance of said Decision No. D1159 and said Federal Power Commission license, the AGENCY has revised the Yuba River Development and intends to construct Hour House Diversion Dam on the Middle Yuba River, Log Cabin Diversion Dam on Oregon Creek, New Bullards Bar Dam and Reservoir and New Colgate Tunnel intake on the North Yuba River, New Narrows Power Plant, and Irrigation Diversion Works on the mainstem of the Yuba River in order to divert and store the water and apply the same to beneficial uses under permits to be issued to the AGENCY and under license from the Federal Power Commission; and

WHEREAS, the construction of the New Narrows Power Plant and Irrigation Diversion Works may affect the spawning area presently utilized by king salmon and steelhead trout runs of the Yuba River and will require the release of water from

Englebright Reservoir and Hour House Dam, Log Cabin Dam and the existing Colgate Dam for the preservation and enhancement of the fisheries of said river system below said dams;

NOW, THEREFORE, in consideration of the mutual covenants herein contained, IT IS AGREED between the parties hereto as follows:

Section 1.1 - The following minimum flows shall be released into the Middle Yuba River immediately below Hour House Diversion Dam for the maintenance of fishlife:

50 cubic feet per second or the natural flow, whichever is less, from April 15 through June 15

30 cubic feet per second or the natural flow, whichever is less, from June 16 through April 14

The above releases shall be measured at a stream gaging station located approximately 500 feet downstream of said dam.

Section 1.2 - The following minimum flows shall be released into Oregon Creek from Log Cabin Diversion Dam for the maintenance of fishlife:

12 cubic feet per second or the natural flow, whichever is less, from April 15 through June 15

8 cubic feet per second or the natural flow, whichever is less, from June 16 through April 14

The above releases shall be measured at a stream gaging station located approximately 500 feet downstream of said dam.

Section 1.3 - The flows stipulated above in Sections 1.1 and 1.2 shall not fluctuate more than plus or minus 10 percent from the respective mean flows in any 24-hour period. The term "natural flow" in Sections 1.1 and 1.2 means the inflow to the respective reservoirs.

Section 1.4 - The following minimum flow shall be released for maintenance of fishlife from the existing Colgate Dam on the North Yuba River:

5 cubic feet per second year around

The flow shall be measured at a stream gaging station located approximately 500 feet downstream of said dam.

Section 1.5 - The AGENCY shall make releases of water from Englebright Reservoir to maintain in the Yuba River immediately below Daguerre Point Dam the following minimum flows for the maintenance of fishlife:

January 1 - June 30 ----- 245 cubic feet per second

July 1 - September 30 ----- 70 cubic feet per second

October 1 - December 31 ----- 400 cubic feet per second

- 2 -

-187-

These flow releases shall be in addition to releases required to satisfy existing downstream water rights and shall be measured over the crest of Daguerre Point Dam and through the fishways at that dam.

Section 1.6 - Water releases for fishlife shall be subject to reduction in critical dry years.

A critical dry year, as used herein, is defined as a water year for which the April 1 forecast of the California Department of Water Resources predicts that streamflow in the Yuba River at Smartville will be 50 percent or less than 50 percent of normal. The critical dry year provisions herein shall be effective from the time the aforesaid forecast is available until the April 1 forecast of the following year.

The water release curtailment schedule for critical dry years will be as follows:

<u>Yuba River at Smartville Streamflow Forecast Per Cent of Normal</u>	<u>Reduction in Water Releases for Fishlife, Per Cent</u>
50	15
45	20
40 or less	30

However, in no event shall water releases for fishlife below Daguerre Point Dam be reduced to less than 70 cubic feet per second.

Section 1.7 - A minimum pool shall be maintained in New Bullards Bar Reservoir at elevation 1730 feet.

Section 1.8 - The AGENCY shall clear vegetation in New Bullards Bar Reservoir from 1700 foot elevation to the 1955 foot elevation.

Where borrow areas are proposed, the top soil shall be stripped first and stockpiled. When borrow operations are completed, the area shall be graded as practicable, and the top soil shall be replaced where the topography permits. Borrow areas on U. S. Government land shall be revegetated with browse species. This stipulation does not apply to those areas which will be inundated by the reservoirs.

Section 1.9 - AGENCY shall mitigate damages to wildlife resulting from project activities in accordance with recommendations of the Department of Fish and Game. The extent of AGENCY'S obligation under this Section will be determined through further investigation and negotiations.

Section 2.1 - During the period January 16 through October 15, flows released by the AGENCY from the Englebright Reservoir for start-up, shutdown and operation of New Marrows power plant shall not fluctuate at an hourly rate of more than 500 cubic feet per second and releases shall be changed as gradually as possible within this hourly period.

- 3 -

-188-

C - 0 6 6 9 6 0

C-066960

Section 2.2 - For flood flows, and uncontrolled flows of tributary streams (Deer Creek and French Dry Creek) the releases from Englebright Dam during the period October 16 - January 15 shall be continuous and uniform, but the scheduled release for the specified period shall be within the limits prescribed below and these releases shall be measured at the same gaging station as described in Section 2.4:

<u>PERIOD</u>	<u>RELEASES - C.F.S.</u>
October 16 - October 31	600 - 1,050
November	600 - 700
December	600 - 1,400
January 1 - January 15	1,000 - 1,850

The release during the specified period shall not vary more than 15 percent from the scheduled uniform release and this variance shall be further minimized whenever possible.

Except in case of emergencies, during years other than critical dry years as defined in Section 1.6, minimum continuous release by the AGENCY from Englebright Reservoir during the period January 16 through March 31, shall be 600 cubic feet per second, subject to the above 15 percent variance.

Section 2.3 - The allowable reduction in the average continuous flow during the operational period of October 15 - 31 shall be minimized and limited to not more than 35 percent of the average flow during the preceding seven day period. The reduction in the average continuous flow during November 1 - 30 shall be minimized and limited to not more than 15 percent of the average continuous flow during the preceding fifteen day period. The STATE shall be furnished with the proposed operation schedule five days before the scheduled release period with further notification of any subsequent change at or before the time it is made.

When the storage and runoff may allow a higher scheduled uniform flow during October and November without a reduction in flow in December, the uniform scheduled release in October and November may be increased.

Section 2.4 - Fluctuations in the streamflow are to be measured at the new Yuba River gaging station below Englebright Dam which will be constructed for the AGENCY by the U. S. Geological Survey at a location below the discharges of the two powerhouses.

Section 2.5 - The requirements of Sections 2.1 through 2.4 shall be subject to re-evaluation and revision at such time as Marysville or other downstream storage reservoir is constructed on the Yuba River.

- 4 -

-189-

Section 3.1 - Instances where the AGENCY or its contractors propose to remove vegetation from a reservoir site, strip earth from the abutments, remove sand or gravel from a stream, wash gravel near a stream or carry on any activity in or along a stream which might result in muddying, silting or allowing to enter the stream any substance, which might injure fish life or fish habitat, the AGENCY shall be responsible for providing and maintaining in effective condition check dams, settling ponds, and such other features as may be required to maintain the fishery values of the streams below such operations.

The AGENCY shall be responsible for its contractor's compliance with Sections 5650, 5948, 12015, 1601, and 1602 of the California Fish and Game Code and other applicable statutes relating to pollution prevention or abatement.

Section 3.2 - Free public access shall be allowed within the proposed project boundary, except in areas where public safety, security of AGENCY'S property, or interference with project operations are the controlling factors.

Section 3.3 - It is recognized by the AGENCY and the STATE that the temperature of water released from the New Bullards Bar Reservoir during the spawning seasons of king salmon in the fall and shad in the spring can have an effect upon mitigation and enhancement of the salmon and shad runs in the Yuba River. The AGENCY shall so locate and operate the power intake and outlet works at New Bullards Bar Dam so as to provide water temperatures of the releases from New Bullards Bar Dam comparable to or better than present values with regard to the fishery resources.

Section 3.4 - AGENCY shall bear the cost of constructing, operating and maintaining fish screening facilities at the Irrigation Diversion Works.

Section 3.5 - Design of facilities referred to in Section 3.4 above will be in accord with the criteria described in Exhibit "A", dated August 9, 1965, attached hereto, and which is made a part of this agreement. If said criteria are revised, whereby the cost of fish facilities is increased, such increase shall not be the responsibility of the AGENCY.

Section 4.1 - The AGENCY will file a copy of this agreement with the State Water Rights Board and with the Federal Power Commission and will request amendment of Decision D1159 and F.P.C. License for Project #2246 consistent with the provisions of this agreement. By the execution of this agreement, the STATE hereby consents to the amendment of Decision D1159 and F.P.C. License for Project #2246 consistent

with the provisions of this agreement.

CALIFORNIA DEPARTMENT OF FISH AND GAME

By 

Director

YUBA COUNTY WATER AGENCY

By 

Ben Rose, Chairman

By 

John S. Sanbrook, Secretary

- 6 -

-191-

C - 0 6 6 9 6 3

C-066963

YUBA COUNTY WATER AGENCY

EXHIBIT "A"

Design Criteria for Fish Facilities
August 9, 1965

Fish Screens

1. A vertical louver type screen shall be provided at the headworks of the South Yuba Canal and a cylindrical, rotating, perforated plate screen shall be provided at the headworks of the North Yuba Canal to divert the fingerling fish from the canals and headworks back into the Yuba River. The fish diversion basins and facilities may be located on the canals a suitable distance downstream of the canal intakes. Each canal or approach channel shall be widened into a basin with a rectangular cross section in which the screen shall be located. The design of the transitions to these basins shall be such as to assure a uniform velocity of approach to the screens. Trash racks capable of removing debris that may clog the screens shall be installed upstream of each screen.
2. The louver screen and structure shall be designed according to the following criteria:
 - Normal velocity of approach - 3.5 feet per second
 - Minimum velocity of approach - 1.0 feet per second
 - Angle of line of louvers to direction of flow - 16°
 - Angle of louver slats to direction of flow - 90°
 - Louver slats - 2.5 inches wide
 - Adequate flow straightness shall be provided
 - Clear spacing between louver slats - 1.5 inches to 2.0 inches
 - Velocity at bypass entrance - 1 to 1.4 times the approach velocity
 - Width of bypass opening, minimum - 8 inches
 - Minimum diameter of bypass pipe - 12 inches
 - The bypass structure shall be of a design which assures a uniform velocity distribution from top to bottom as well as a transition of uniform flow into bypass pipe.
 - Provisions shall be made for cleaning the louver screens under operating conditions.

3. The cylindrical, rotating screen shall be designed according to the following criteria:

3 square feet of perforated plate shall be necessary for each cubic foot per second of diversion.

The perforated plate shall have $5/32$ inch holes at $7/32$ inch centers, staggered.

The operating peripheral speed of the screen may range from 10 f.p.m. to 30 f.p.m.

Width of bypass opening, minimum - 8 inches

Diameter of bypass pipe, minimum - 12 inches

Velocity at bypass entrance - 1 to 1.4 times the approach velocity

Provisions shall be made for removing, maintaining and adjusting the cylindrical screen in a dewatered condition.

- 2 -

-193-

ALL NEW FROM
HERE ON !!

APPENDIX VI

RESULTS OF PHABSIM AT SELECTED
IFIM TRANSECT SITES FOR ASSESSMENT OF
UPSTREAM MIGRATION CONDITIONS

Table VI-2.
Height of stream channel to water surface
elevation (ft) at Daguerre Point Dam IFIM
Transect 1 and Transect 2.

Distance from left streambank (ft)	Daguerre Dam IFIM Transect 1			Daguerre Dam IFIM Transect 2		
	100 cfs ^b	50 cfs ^b	35 cfs ^a	100 cfs ^b	50 cfs ^b	35 cfs ^a
0	2.27	2.45	2.52	0.21	0.40	0.47
5	-0.53	-0.35	-0.28	-1.19*	-1.00*	-0.93*
10	-0.93	-0.75	-0.68	-1.29*	-1.10*	-1.03*
15	-0.83	-0.65	-0.58	-1.19*	-1.00*	-0.93*
20	-0.73	-0.55	-0.48	-0.89	-0.70	-0.63
25	-0.83	-0.65	-0.58	-0.39	-0.20	-0.13
30	-0.73	-0.55	-0.48	0.01	0.20	0.27
35	-0.63	-0.45	-0.38	0.21	0.40	0.47
40	-0.53	-0.35	-0.28	0.21	0.40	0.47
45	-0.33	-0.15	-0.08	-0.19	0.00	0.07
50	-0.33	-0.15	-0.08	-0.39	-0.20	-0.13
55	-0.23	-0.05	0.02	-0.09	0.10	0.17
60	-0.13	0.05	0.12	-0.19	0.00	0.07
65	-0.63	-0.45	-0.38	-0.19	0.00	0.07
70	-0.53	-0.35	-0.28	-0.39	-0.20	-0.13
75	-0.93*	-0.75*	-0.68*	-0.39	-0.20	-0.13
80	-0.73*	-0.55*	-0.48*	-0.69	-0.50	-0.43
85	-0.53	-0.35	-0.28	-0.59	-0.40	-0.33
90	-0.63	-0.45	-0.38	-0.69	-0.50	-0.43
95	-0.43	-0.25	-0.18	-0.89	-0.70	-0.63
100	-0.83	-0.65	-0.58	-0.79	-0.60	-0.53
105	-0.63	-0.45	-0.38	-0.79	-0.60	-0.53
110	-0.53	-0.35	-0.28	-0.79	-0.60	-0.53
115	-0.63	-0.45	-0.38	-1.09	-0.90	-0.83
120	-0.73	-0.55	-0.48	-0.79	-0.60	-0.53
125	-0.63	-0.45	-0.38	-0.59	-0.40	-0.33
130	-0.63	-0.45	-0.38	-0.79	-0.60	-0.53
135	-0.53	-0.35	-0.28	-0.89	-0.70	-0.63
140	-0.53	-0.35	-0.28	-0.89	-0.70	-0.63
145	-0.63	-0.45	-0.38	-0.49	-0.30	-0.23
150	-0.53	-0.35	-0.28	-0.29	-0.10	-0.03
155	-0.63	-0.45	-0.38	-0.29	-0.10	-0.03
160	-0.83	-0.65	-0.58	-0.39	-0.20	-0.13
165	-0.73	-0.55	-0.48	-0.49	-0.30	-0.23
170	-0.83	-0.65	-0.58	-0.09	0.10	0.17
175	-0.63	-0.45	-0.38	0.31		
180	-0.73	-0.55	-0.48			
185	-0.43	-0.25	-0.18			
190	-0.13	0.05	0.12			

^a Measured depth
^b Projected depth based on PHABSIM model results
* Channel thalweg

Table VI-3.
Height of stream channel to water surface
elevation (ft) for the Simpson Lane
Critical Riffle thalweg at 84 cfs.

Distance downstream along thalweg (ft)	Channel thalweg profile below WSEL (ft)
0	-0.80
10	-0.70
20	-0.75
30	-0.80
40	-0.75
50	-0.70
60	-0.75
70	-0.80
80	-0.75
90	-0.75
100	-0.80
110	-0.70
120	-0.85
130	-0.80
140	-0.80
150	-0.75
160	-0.85
170	-0.90
180	-1.10
190	-0.90
200	-0.75
210	-0.70
220	-0.70
230	-0.60
240	-0.65
250	-0.60
260	-0.70
270	-0.70
280	-0.80
290	-0.90